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The Operating Record — A Sleuth or a Traffic Officer?

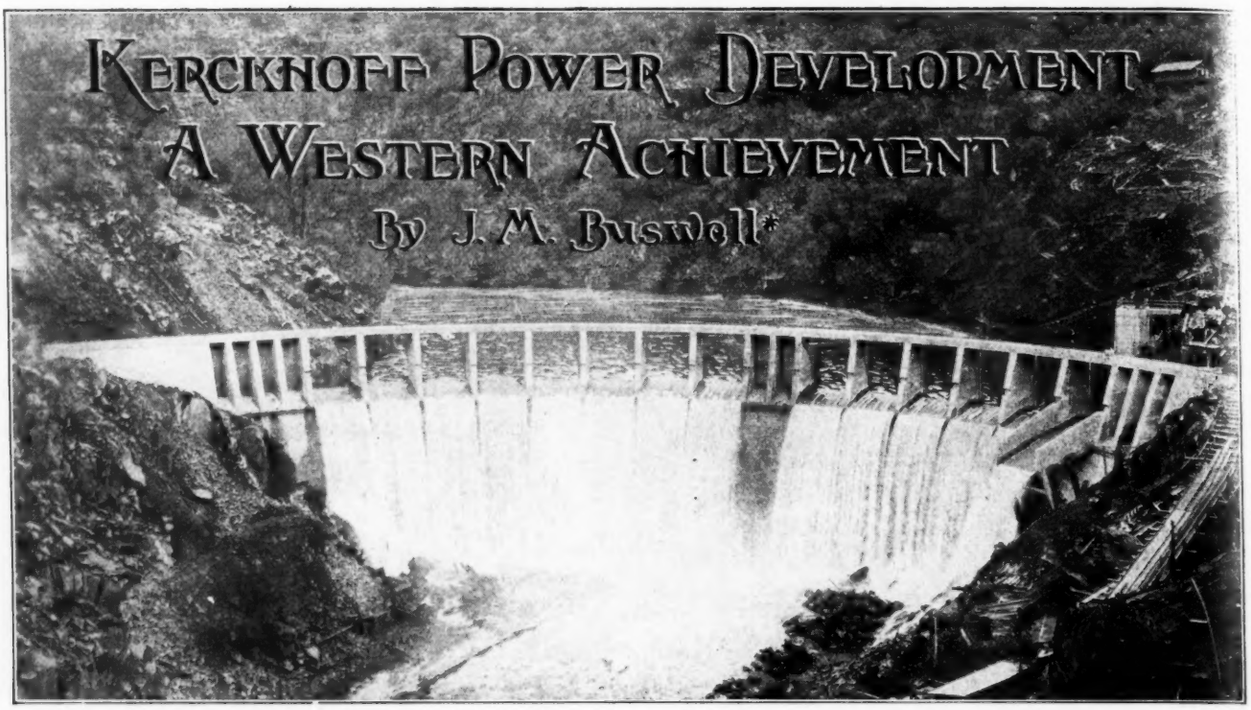
IN SOME organizations the engineer of tests and his staff are looked upon rather as plain clothes men who prowl about the plant and undertake to find operating deficiencies for report to the management. Under other circumstances the operating force recognizes the great value of tests and records of plant performance. It uses the work of the inspection department as a traffic guide, gladly regulating the course of plant operation according to results reported, just as the chauffeur regulates his movements by the "stop" or "go" of the crossing officer's semiphore.

Operating records should under no circumstances be made an end in themselves. A most beautiful and impressive set of records can easily be built up by a careful engineer of tests, but this achievement represents no advantage at all unless real use is made of the findings. Not long ago a well-known mechanical engineer was called in for advice by one of the most elaborately organized municipal water-works departments. He found that this department had a splendid engineer of tests and staff, who could present for his examination graphic records pertaining to every detail of plant operation for years past. Roll after roll of chart was brought out for inspection, showing the ups and downs in every measurable factor. But it quickly developed that the operating force had looked upon this engineer of tests and his records as a spy set to catch them in error, and that so far as possible they had undertaken to discredit his records and had succeeded more or less completely in having them ignored. Under such circumstances it is not surprising that the eminent consultant was sorely needed by the staff.

The operating record of any plant, be it boiler house, engine room or factory, is a most valuable tool both to the management and to the operating force. To dull this tool by misuse or to allow it to lie and rust upon the shelf is most unfortunate. Indeed, either of such practices is likely to be very expensive.

Kerckhoff Power Development—A Western Achievement

By J. M. Buswell*



A 45,000-Hp. Hydro-Electric Development Completed in 15 Months—Pressure Tunnel 18 by 18 Ft., 16,875 Ft. Long—Pieces of Equipment Weighing 58,000 Lb. Transported Over Mountain Roads—Airplane Used in Making Surveys—Project Completed in Record Time Under Most Unfavorable Conditions.

THERE is considerable interest connected with the design, construction and test of the recently completed Kerckhoff hydro-electric development of the San Joaquin Light and Power Corporation, of Fresno, Cal. This development is about forty-five miles northeast of Fresno on the San Joaquin, one of the largest rivers in the state. The project includes a concrete, constant-angle arch dam across the main San Joaquin River bed; an 18 x 18-ft. unlined pressure tunnel 16,875 ft. long; a steel, triple-penstock line; a reinforced-concrete power house, housing three 15,000-hp. vertical-shaft turbines to operate under a head of 315 to 340 ft. and directly connected to 14,200-kva. vertical-shaft generators; an outdoor high-tension step-up transformer and switching station; 206 miles of 110,000-volt transmission line and of four substations, tying in to existing 60,000-volt and 110,000-volt network. When deciding upon the hydraulic development, there was the choice of providing a simple diversion with a rather small dam located at the company's existing No. 1 power house, with an open conduit from there part or all of the way to the head of the penstock for this plant, but decision was made in favor of the dam. This would provide a certain amount of storage to absorb the fluctuation in the river flow, which varies during the twenty-four-hour period on account of the run-off decreasing during the cold night hours and on warm days amounting almost to a freshet. This storage would also enable the plant to be so operated during the low-water season as to carry a high peak by conserving the water during part of the day while the run-off is light; that is, by letting the steam stand-by plants carry the load while the reservoir is allowed to fill up. When the peak comes on beyond the steam-plant and other reserve capacity, the hydraulic plant can be operated at a point beyond the stream flow, which, of course, would draw down the reservoir; but by the time the peak dropped off, the balance of the plants would be able to take care of the load. This may or may not be necessary, but even the small amount of storage makes it possible. In the second place the reservoir displaces several miles of open ditch on rather rough mountainside, which would be expensive to build as well as to maintain and operate; and this is all eliminated by the dam, the maintenance and

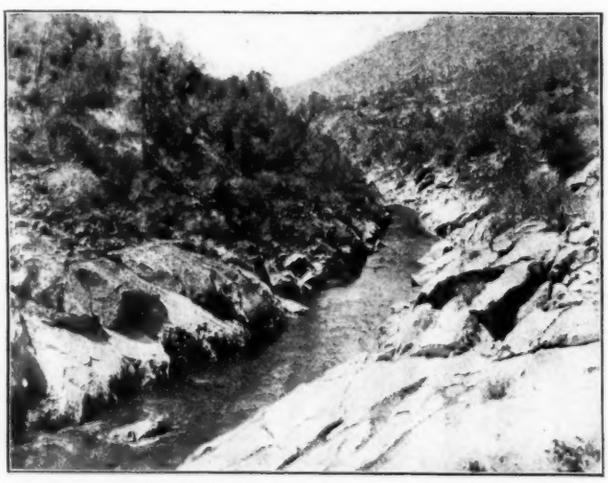


FIG. 1. POWER-HOUSE SITE AT LEFT; PHOTO TAKEN AT EXTREME LOW WATER

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operation of which will, of course, be negligible; and in addition the available head at the power plant is increased by the amount of drop that would have been required in the several miles of ditch to give even a flow of 1,750 second-feet, which is the full-load requirement. On the other hand, it was not considered economical to build a tunnel of this size through to a diversion dam at the No. 1 power house because the additional head (the fall through a longer tunnel) would undoubtedly have made necessary the concrete lining of the tunnel throughout its length.

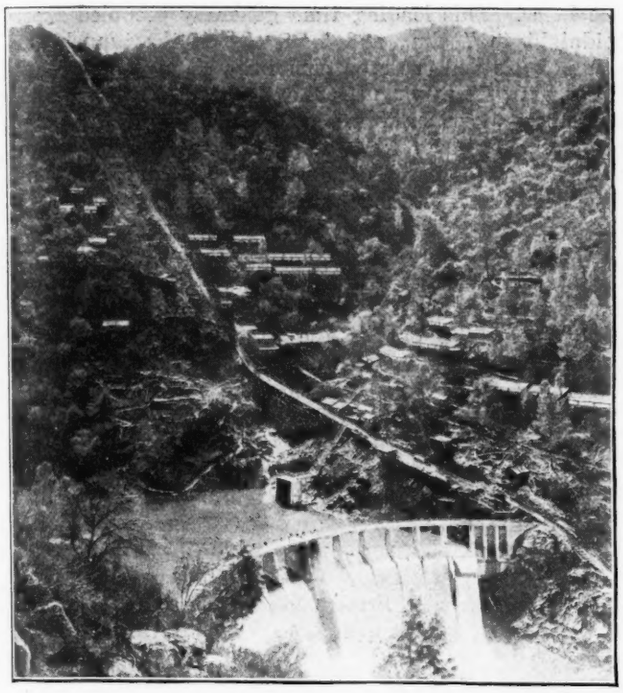


FIG. 2. DAM BEFORE RADIAL FLOOD GATES WERE INSTALLED

Dam and north portal were completed less than six months after drilling of test holes, excepting the radial flood gates which were installed the following summer, during lower-water period, before the tunnel and power house were ready, fifteen months after the work was first started.

The dam (see headpiece and Figs. 2 and 3) is in a narrow horseshoe of the river, where it winds through a granite mountain, and contains 23,489 cu.yd. of concrete, which is about one-half of the quantity that would be required for a gravity dam at this place. This dam is 570 ft. along the top, 140.5 ft. in total height above the original river bed, and the crest is constructed on a parabolic curve, with a lip extending out over the downstream face in order to discharge the overflow a distance away from the face and free of the toe of the dam, into a pool formed below the dam by casting excavation material downstream in such a way as to form an embankment and provide a pool about thirty feet deep, which eliminates the danger of the falling water cutting the rock at the toe of the dam. Above the crest there are provided fourteen 14 x 20-ft. Taintor (radial) gates. A concrete log chute, shown to the right in the headpiece, was constructed, extending out from the downstream face of the dam beyond one of the Taintor gate openings in order to take care of driftwood which sometimes comes down the river with the first heavy floods.

At elevation 994.5 ft. is the top of the dam, Fig. 3, forming a floor over the walls which separate the Taintor gates, and along this floor there is provided a track on which is operated a specially designed motor-driven hoist for operating the Taintor gates by means of chains that extend up through small openings in the floor. Near the bottom of the dam there are three 72-in. rising-stem sluice gates. The Taintor gates, when open, will permit the discharge of 100,000 cu.ft. per sec., this capacity being amply safe for any possible floods.

When the gates are closed, as they normally will be, and the lake raised to their top, its surface elevation will be 985 ft., which is approximately that of the floor of the tailrace of the company's existing No. 1 power house about two miles up river, thus forming a storage impounding 4,000 acre-feet of water, approximately 3,000 of which is above the Kerckhoff pressure tunnel. This available part will operate the new Kerckhoff plant nearly twenty-four hours at full load, which requires 1,500 cu.ft. per second.

As is well known, all the power companies in the West have suffered for the last two years on account of power shortage, and in order to relieve this condition it was decided to get the Kerckhoff development into operation at the earliest possible time. In addition, it was necessary to complete the foundations of the dam during the low-water period before the fall rains raised the waters, interfering with construction.

FIG. 3. RADIAL FLOOD GATES INSTALLED IN DAM

Radial flood gates are operated by an electrically driven hoist mounted on a traveller which moves along the dam on a track, the three 72-in. sluice gates also being operated from the top of the dam.

At the time R. C. Starr was called to take charge of this development, only rough preliminary surveys had been made, and under his direction, on May 20, 1919, work was started on the engineering, and at the same time diamond drilling at the dam site selected was started. By July 20 test holes had been drilled

FIG. 4. SURGE TANK CUT IN SOLID ROCK

Looking up through the milk-bottle shaped surge tank which rises 70 ft. from the roof of the tunnel through solid granite to the hill-slope above.

for the foundation of the dam, camps constructed, roads built, etc., and on that date excavation of the dam was begun. An incline was built down a steep grade immediately at the dam site (see Fig. 2), and even before that was completed and during the heat of the summer, in this box-canyon, crews of men worked feverishly, dragging and lowering compressors and other machinery down the steep mountainside amid such dangers as loosened boulders, poison oak, etc., and on Aug. 12 the first concrete was poured. Work went on day and night until the dam was completed on Dec. 15 of that year, marking the accomplishment of a feat that is probably unparalleled. W. A. Whitmire was personally responsible for pushing the construction work on the dam to such rapid completion.

The north portal, or intake of the tunnel line, is closed by a substantial gate and grizzly and is located close to the dam, as shown at the left in Fig. 3. The tunnel extends from this point 16,875 ft. entirely through hard, gray-granite formation, requiring no timbering during driving, nor lining. This tunnel has an average driven cross-section of 320 sq.ft.—approximately 18 ft. square—designed for 2,100 cu.ft. per second.

Near the south end, Fig. 5, where the triple penstock line is concreted into the tunnel, a surge tank was constructed, called the "Milk Bottle" by the construction men, as it is of that shape (see Fig. 4). It is 40 ft. in diameter at the tunnel roof, extending upward approximately 70 ft., and approximately 17 ft. in diameter at the top, where it opens out on the side of the mountain to form a spillway. The chamber itself forms a surge tank to absorb or dampen out surges in either the pipe lines or tunnel. This bottle-shaped shaft is hewn out of the solid granite mountain above the tunnel.

The method used in driving the tunnel is known as the "Heading and Bench Method," under which a bench about fourteen feet long and seven or eight feet from the roof is carried forward, on which the "heading crew" drills from thirty-five to forty holes fifteen to twenty feet deep into the heading, those near the center pointing toward each other and coming together at the bottom. These are called the "cut holes," and when shot throw a wedge-shaped piece of the rock, and are drilled while the former shot is being mucked out in front of the bench.

After the muck is cleaned up, the "bench crew" drills from twelve to sixteen holes horizontally into the bench, requiring about four hours, after which this crew shoots the holes. This loading time generally occupied from midnight to 7 a.m., and by 8 o'clock the tunnel was clear of gas and the crew sent in to clean up the track preparatory to moving the shovel ahead. By 10 o'clock the steam-shovel crew would be called and start operation, and by noon the heading crew was ready to go, and later on the bench crew went in. A complete round was made in each twenty-four-hour period, in this manner making sometimes as high as 19 ft. progress.

The mucking was done with Marion 40-in. steam shovels operated with air at 100 lb. The very skillful and efficient manner in which these shovels were operated represented one of the greatest factors in the remarkable record made in driving this tunnel.

Tunnels of this size, where shovels have been used for mucking, have invariably been constructed by first driving a pioneer heading outside of the required tunnel section, and have cost approximately 50 per cent more per foot where driven in similar gray granite, although the wage scale and cost of powder on this job was 100 per cent higher than was paid before the war.

The triple penstock, consisting of three steel-pipe lines 950 ft. long, 8 ft. in diameter at the portal and 7 ft. at the wheels, was completely erected, riveted, calked

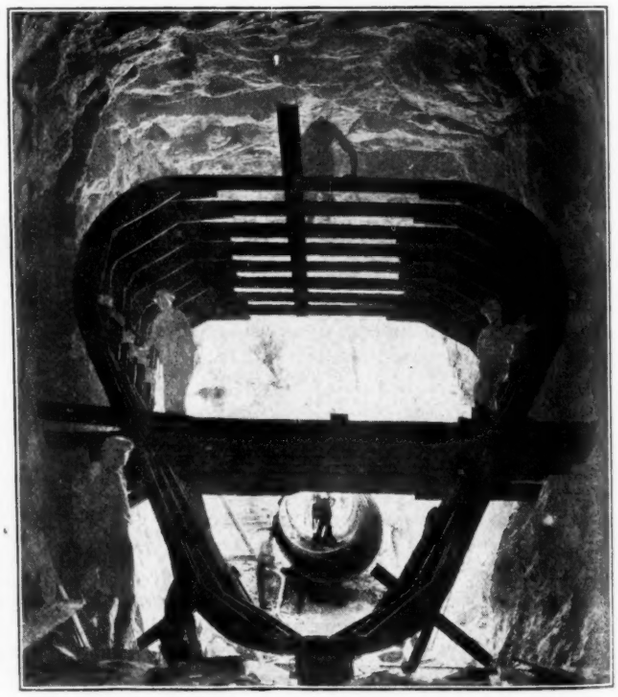


FIG. 5. TRIANGLES IN SOUTH PORTAL FOR SUPPORTING THREE STEEL PENSTOCKS

At the south portal of the tunnel the three eight-foot penstock pipes were cemented into the tunnel in a triangular position, coming to a horizontal plane a short distance beyond.

and anchored in thirty-two days by the power company's construction crew. There are no standpipes on these lines, there being provided a surge tank a little inside at the point where these lines are cemented into the south portal.

Air relief valves are installed on the top of each pipe line at two points to permit air to enter the penstock lines to prevent collapsing. At the lower end of each line where it enters a turbine there is provided an 84-in. butterfly valve, electrically controlled from the switchboard and designed to withstand full penstock pressure if it is desired to empty the turbines for inspection or repairs without emptying the penstock.

At the upper end of the pipe lines there are installed three 8-ft. rising-stem gate valves provided with bypass valves, Fig. 6. They weigh 60,000 lb. each, complete, and were designed and built in record time. They are electrically operated from the power house, being so interconnected as to require the main gates and the bypass valves, which are also electrically equipped, to be operated in the proper sequence. The reinforced-concrete power house is located in a box-canyon, Fig. 1, through which the San Joaquin River flows; the main floor, 100 x 36 ft., is at elevation 675 ft. above sea level, the roof being 45 ft. above and the turbine floor 23 ft. below. The building is constructed on a site entirely excavated out of the solid granite side of a mountain, inaccessible by road, and to which access was obtained by building an incline railway 1,000 ft. long (Figs. 6A and 11). This railway has a maximum grade of 100 per cent just before it enters the power house, and at the door of the power house it straightens out to a level, under the crane. A chamber entirely excavated down into solid granite to the low-water river level forms the turbine room, the generator floor above being constructed as an arch over this cavern the sides of which did not require concreting, Fig. 7.

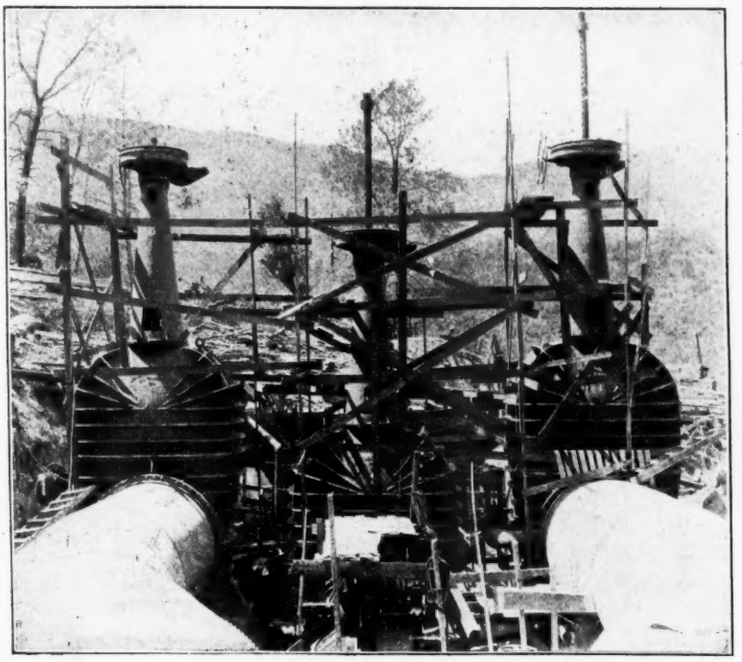


FIG. 6. RISING-STEM GATE VALVES FOR PENSTOCKS

Eight-foot rising-stem gate valves weighing 60,000 lb. each, motor operated and with motor operated bypass valves, were installed close to the tunnel.

The unusually small floor space provided for three units of such large capacity is rather striking and causes considerable comment, but all the equipment is so compactly built and placed that there is ample room in the building for all purposes. In fact, the design is a striking example of compactness, efficiency and economy in every way and is credited to the power company's engineering department on this project, of which B. F. Jakobsen was chief designing engineer.

Three 15,000-hp., vertical turbines, direct-connected to 14,200-kva. generators; two 500-hp. turbines direct-connected to 300-kw. exciters, on top of each of which is mounted a 15-kw. control-current generator; oil-pressure governors and pumping sets make up the main equipment of the plant (see Fig. 9). An excellent record in delivering the equipment within the schedule time was made by the manufacturers in spite of difficulty due to labor and material shortage. The manufacturer's erector completely installed the turbine, generator and exciter equipment, using men furnished by the power company, in less than ninety days; and with the aid of the power company's riggers, installed the first two turbines in twenty days without the use of the crane, which had not then been installed. The winders completed the stators on the job in fourteen days per machine. All of this is considered excellent erection time. As indicated in Fig. 7, the turbines are of the vertical-shaft, single-runner "Francis" type, equipped with pressure-relief valves, which are automatically operated by the governor or by excessive increase in pipe-line pressure due to surge or load changes, etc. The governors are of the latest type manufactured by the Allis-Chalmers Manufacturing Co., with the flyballs mounted on the mainshaft and mechanically connected to the relay and floating valves, which control the oil pressure in the gate-operating cylinders. The latter in turn operate the wickets and relief valve. Elimination of driving arrangement by placing the governor actuating parts on the mainshaft is a distinct improvement.

Bolted immediately to the butterfly valve at the end of the penstock line is the 84-in. spiral casing, so that all acceleration to the required velocity will occur in the casing, the water passing through the butterfly valve at penstock velocity. The casing, which is in two parts, and the speed ring, which is one solid casting, weigh 85,000 lb. The weight of the casing, speed ring, etc., is carried on a foundation ring, which in turn is carried on, and bolted to, the concrete foundations.

Steel-plate draft tubes are used, discharging straight into tunnels driven through the solid rock to the river, these tunnels measuring 10 x 12 ft.; and openings are provided in the steel draft tubes for inspection of the runner and other parts from the discharge side.

Special composition water bronze was used in the construction of the runners, the guide vanes being of cast steel with solid-steel stems. These gates are oper-

ated by two regulating cylinders for each unit, mounted on top of the spiral casings to which they are bolted, providing compact, self-contained units, controlled by the governor.

Each main unit is provided with its own motor-driven governor oil pump, pressure and receiving tanks, and a hand-operated oil pump. These pumps are inter-

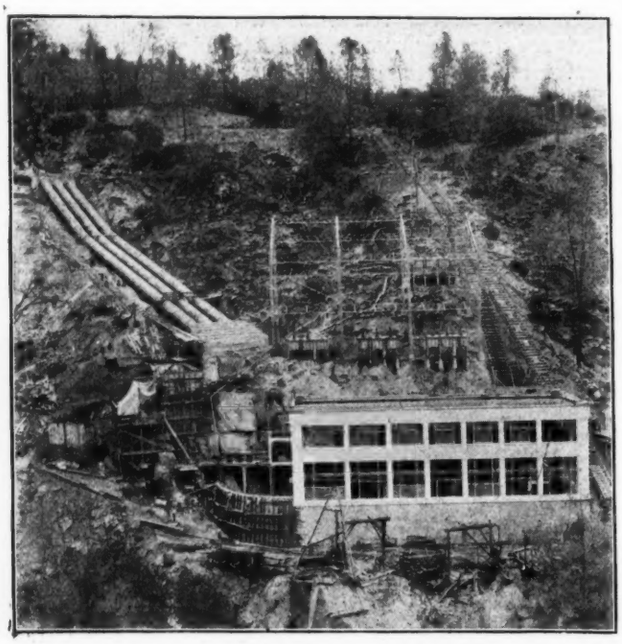


FIG. 6A. EXTERIOR OF POWER HOUSE

The Kerckhoff power house is on a bench excavated out of the granite hillside, and the 110,000-volt switch structure is built on an angle of 45 deg. An incline railway, on the right, was constructed, having a maximum grade of 100 per cent. The penstocks 8 ft. in diameter are shown on the left.

connected, however, so that either may be used on any machine.

The weight of the rotating elements complete, together with the reaction from the runner due to the water passing through the wheels at maximum load, is carried on 29-in. diameter special Kingsbury bearings, the friction loss of which at normal speed and with 150,000 lb. load, rotating and thrust, is approximately 20 hp. These are the first bearings of this type which are self-contained as to lubrication. They are equipped with cooling coils to keep the oil temperature within proper limits, the power company's engineering department specifying this arrangement in order to eliminate the objections in connection with external oil-circulating and cooling systems, which may permit foreign particles and scale from the pipes getting into the oil. These are of necessity expensive, requiring pumps, coolers, filters, etc., and one of the principal features considered was that with the external-pressure circulating systems the oil is broken down and has much shorter life.

This thrust bearing is mounted on the upper bridge over the generator, and immediately below it is located the upper guide bearing so designed as to be removable without disturbing the thrust bearing. The second, or lower, guide bearing is in the lower generator spider, on which are also mounted three friction asbestos-lined brakes, operated by a system of levers controlled by a handwheel on a column alongside the generator. All of the guide bearings are lubricated by a small pump located in the pan below the lower guide bearing of each unit, these pumps being geared to the mainshaft and easily accessible. The pans form large reservoirs from which the pumps raise the oil to the top of the upper bearing down through which it flows. After this it is conducted to the top of the lower bearing through pipes that revolve with the shaft, being placed through the hub of the rotor spider. The wheel bearing is of lignum-vitæ and is split so that it may be removed without disturbing the rotor or shaft.

All three main generators are of the vertical type, three-phase 60-cycle 6,600-volt 1,240-ampere, with a maximum rating of 14,200 kva. at 80 per cent power factor. The stator winding is insulated with mica in the slots and in accordance with Class B specification, A.I.E.E., good for 125 deg. C. continuously, and both ends of each phase winding are brought out to make them easily accessible for any combination of metering and relay equipment, and grounding. Ventilation of the generators is accomplished by taking air from the room at the top and from the turbine cavern below and discharging it out through the sides of the stator's frame into a sheet-steel casing which surrounds the yoke and conducts the air outdoors, openings being provided, however, for warming the power house in the winter.

The entire rotating element is good for 100 per cent overspeed, and they were actually tested in the pit at 690 r.p.m., which is the runway speed. At normal

FIG. 7. INTERIOR OF TURBINE ROOM

Two of the three turbines were erected in this cavern in twenty days before the crane was installed. This cavern is cut out of solid granite, down to low-water level.

speed, 360 r.p.m., the peripheral speed is 11,000 ft. per minute.

Excitation is supplied by two vertical waterwheel-driven shunt-wound 300-kw. exciters, which are amply large to provide excitation for all three main units. On top of each of these exciters there is mounted a 15-kw. 125-volt compound-wound generator, either of which will furnish all control current for operating oil

switches, governors, etc. These exciters are driven by 500-hp. 900-r.p.m. vertical turbines similar in type to the main units except that they are not equipped with governors, complete electric and hydraulic control being provided at the switchboard, it being possible to depend on the relation between the speed and torque, and the rather wide range of speed through which it is possible to operate the exciters without trouble.

When the exciter set is operating at a point on the drooping side of the efficiency curve, where increased speed results in lower efficiency, it is readily seen that a rejection of load by the Tirrell regulator would result in the exciter set speeding up until the speed comes to a point where, on account of reduced efficiency, the given gate opening would correspond to the reduced horsepower, which would prevent further speeding up. As the load on an exciter varies but little, a governor normally operates in a very short range within which parts wear free, the governor sticking and refusing when called on by trouble to act beyond that range, requiring close supervision by operators in any case. No complete load tests were conducted at the factory, but core loss, windage, friction, etc., were measured by input to a vertical direct-current motor driving a machine, and from these results an efficiency was predicted of 97.1 per cent at maximum load and 80 per cent power factor, on the generators.

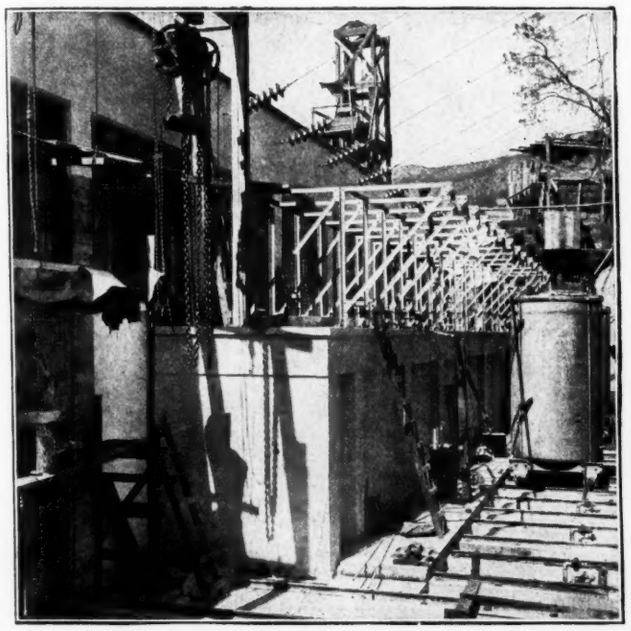


FIG. 8. TRANSFORMERS AND BUSSES LOCATED OUTSIDE POWER HOUSE

At the rear of the building is located the switch room, on top of which are the 6,600-volt transformer busses, serving the nine 5,000-kva. transformers.

On Sept. 29, 1920, the power company conducted a test to determine if the guaranteed efficiency had been met. The chemical, or salinity, method was used, and although the conditions were rather unusual for this method, remarkably uniform results were obtained. These tests were conducted by H. R. Stevens, who had charge of power-house construction.

Because of shortage of power in California, it was decided not to interrupt the operation of the power plant as far as the output to the system was concerned, and the test was conducted on one unit operating on a fixed gate, with the generator tied into the system, which of course held the speed variation down and provided for a very satisfactory uniform block of load at a constant speed for a period sufficiently long to enable the taking of necessary readings and samples, etc. During the test elevations were read at the lake, and also in the surge tank at the head of the penstock, in this case a float being used attached to a steel tape running over a pulley so that readings could be taken against an established benchmark.

A platform was constructed in the stop-log shaft, which extends vertically down to the tailrace tunnel, and from this platform the elevation of the water in the tailrace was accurately read, and also, gages were connected through separate piezometer openings at different points around the circumference, the center line of these three gages being established at a given elevation. For providing the salt solution sufficient to make all the tests, a 10,000 gal. wood-stave tank was erected, close by the top of the pipe line, containing 7,500 gal. of water to which was added six tons of common salt, after which the solution was agitated for sixty hours by air released from submerged pipes, under pressure. The resulting solution contained 86,543 parts of salt to 1,000,000 parts of water, the density being 1.09248. This solution was then allowed to flow into a barrel

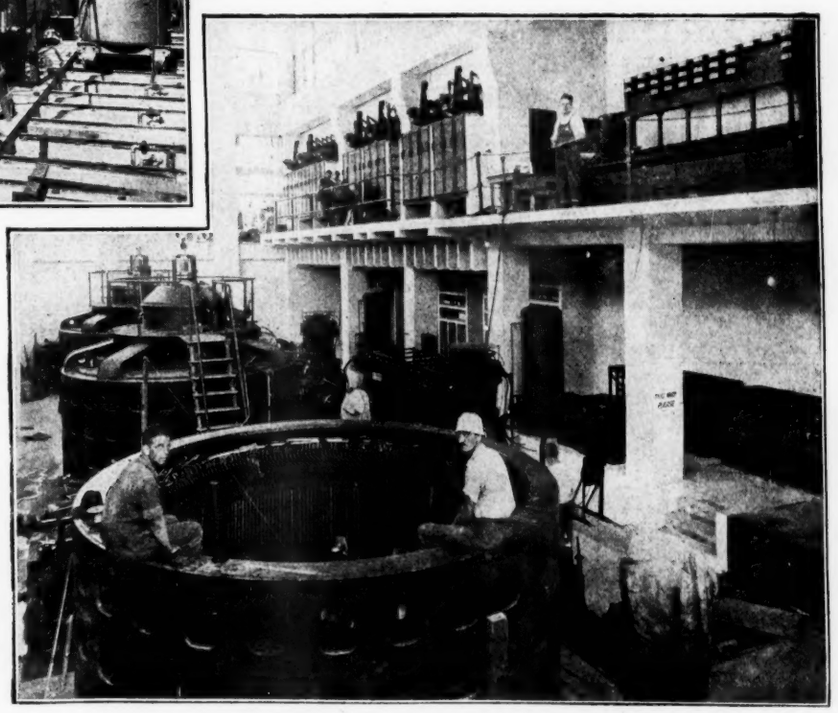


FIG. 9. INTERIOR OF GENERATOR ROOM

Interior of the Kerckhoff power house is a model of compactness and efficiency of design. This view shows the main units, exciters, governor-oil pumping sets, rheostats and auxiliary board, on the main floor, with the bench control-board and low-tension switches on the gallery.

mounted on a frame and provided with an orifice at the bottom and a marker at the top, the barrel kept filled to the marker while the solution flowed freely out through the orifice, falling into a second barrel from which it was discharged by a 3-in. 150-g.p.m. four-stage centrifugal pump, through quick-opening valves and regulating valves, either into the penstock or back to the supply tank or to a third barrel mounted on a calibrated platform scale.

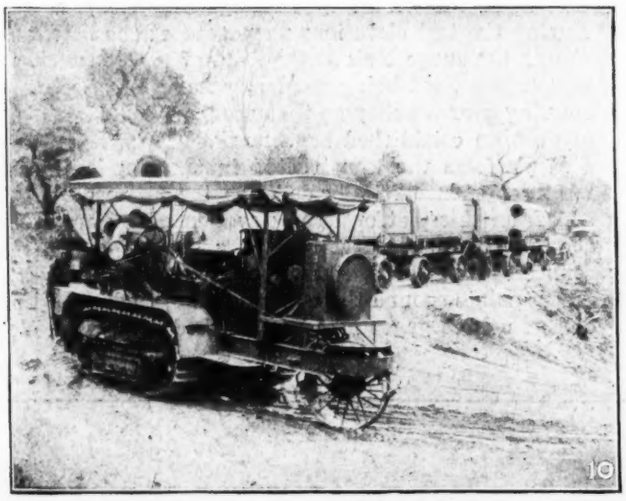
The orifice was checked by weighing the solution that passed through in a given time, then the solution was allowed to pump into the supply tank until a test signal was given, when the quick-opening valves were thrown over and the solution discharged into the penstock through four ½-in. nozzles arranged around the circumference.

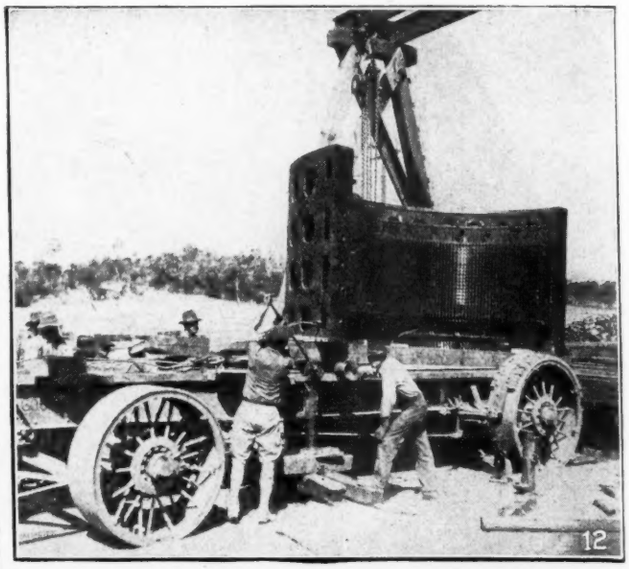
This arrangement was located near the top of the penstock. The rate was 14.905 lb., or 0.2185 cu.ft. per second.

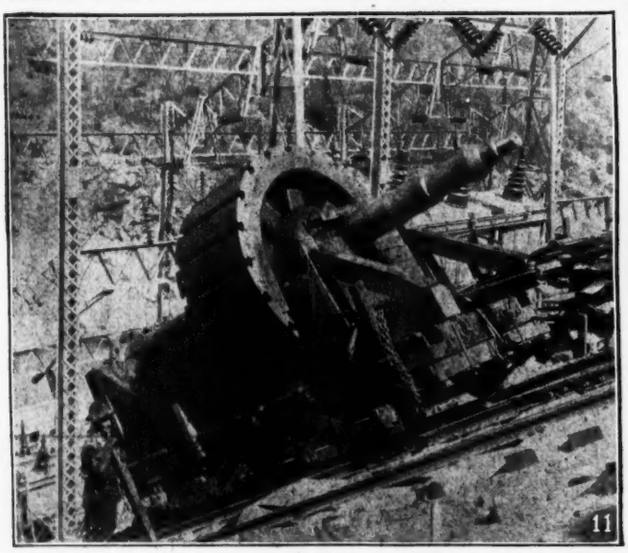
By keeping record of the load of the other units during the test, it was possible to include a determination of the tunnel friction loss, which was 5.38 ft. and velocity, which was 2.37 ft. per second, at 760 cu.ft. per second.

The resulting efficiency was found to be in excess of the guarantees by a considerable margin. The guaranteed maximum turbine efficiency was 87.5 per cent at 0.8 gate, 332-ft. net head, corresponding to approximately 13,000 hp. Actual turbine efficiency at 0.8 gate opening and 329.387 ft. net head was 90.1 per cent, when the output was 16,260 hp. At a generator efficiency of 97.62 this represented 11,860 kw. The discharge was 483.5 cu.ft. per second, and the penstock loss 4.7 ft. At full gate opening the turbine developed 18,680 hp. at 327.374 ft. net head, discharging 575 cu.ft. per sec., the efficiency of the turbine being 87.45 per cent, the generator output 13,610 kw., the penstock loss 6 ft. and the velocity 12.8 ft. per sec. The maximum generator output to date is 14,500 kw. on one machine.

All of these results show that the machines are above rating, that for a given gate position a greater output







FIGS. 10 TO 13. SHOW METHODS OF TRANSPORTING EQUIPMENT

Fig. 10—Six ten-ton trailers were operated in a train, shown here loaded with transformer cases, drawn by a 75-hp. caterpillar. Fig. 11—An incline railway 1,000 ft. long, having a maximum grade of 100 per cent (45 deg.), was constructed to serve the power house, which was inaccessible by road. The 29.5-ton rotors were in this way sent down. Fig. 12—Loading a half of a generator stator on a 35-ton special trailer, by means of which the 29.5-ton rotors were also transported over a mountain road, having a maximum grade of 12 per cent. Fig. 13—5-ton truck, with 5-ton dolly, loaded with 22-ft. section of the eight-foot penstock pipe, weighing about eight tons.

is generated but without a corresponding full increase in use of water; and it is contemplated to add another, perhaps smaller, unit at some future time in this power house; the tunnel, having an average section of 320 sq.ft., will accommodate 2,100 second-feet at only 6.6 ft. velocity.

The main control board is of the bench type, flanked with a pedestal-type Tirrell voltage regulator. Watt-hour meters and various combinations of relays are located on the rear of the bench. This entire switchboard was wired in completely in the field in fourteen days by the employees of the power company's construction department, under H. L. Wood. A mimic bus is located on the bench-board, and on the front of this board are the testing receptacles connected with the temperature exploring coils, which are inserted in the generator windings. The 6,600-volt layout includes a main bus and, for each generator, a transfer bus which permits connecting the generator direct to its corresponding transformer bank and operating these as a unit on one outgoing 110,000-volt line independent of the main-station bus; and there are disconnecting switches provided, so that, when so operating, a unit may be closed in to the main bus and changed to normal parallel operation without interrupting its load. This scheme is nearly as flexible as a double-bus system, but much less expensive; and while it may be conceded that a double-bus layout is preferable in connection with a switching or distributing center, it is not considered so important in a generating station containing its equipment in comparatively few units. Generators and step-up transformers are protected by differential relays in such manner as to isolate faulty apparatus. The generator and exciter field rheostats, field switches, governor control, hydraulic gate opening and closing mechanism, both on the main and exciter units, are remote-controlled from the switchboard.

The high-tension layout is outdoors on the hillside, Fig. 6A, which was so steep that the steel structure, which consists of three bays, had to be designed with the supporting trusses and braces built at an angle of 45 deg., so as to give proper clearance without requiring expensive excavation in the granite mountainside.

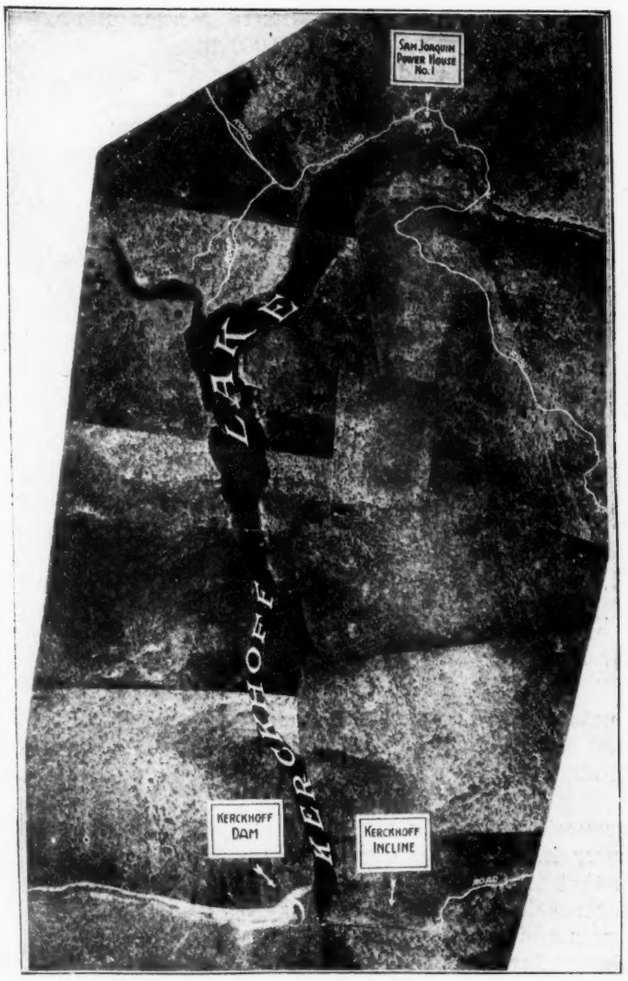


FIG. 14. AERIAL PHOTOGRAPHIC ASSEMBLAGE KERCKHOFF DEVELOPMENT

This is a reduced reproduction of a "mosaic" map made up of photographs taken from the air at 7,000 ft. elevation, showing the Kerckhoff lake, dam, etc. Similar "mosaics" are now being completed over the San Joaquin Light & Power Corporation's Kings River project.

There are nine step-up transformers, arranged in three banks, and having a capacity of 5,000 kva. each, wound for 6,600-volt delta to 127,000-volt "Y." They are located outdoors on a bench cut in the steep mountainside close to the rear wall of the power house, Fig. 8. Catch basins are arranged in such a manner that the oil from an exploded tank will run away from the transformers and be discharged into the river. As two banks of these transformers will carry the load of all three generators without serious overheating, it was not considered necessary to provide a spare unit. There are two outgoing 110,000-volt transmission lines, one extending south approximately 140 miles to McKittrick in the lower end of the San Joaquin Valley, near Bakersfield, near where the company is now completing a 30,000-kw. gas-burning steam power plant, and at which point connection is made to the lower end of the existing 60,000-volt network. [For a description of the Bakersfield gas-fired steam plant see *Power*, Dec. 7 issue.] The other line extends from the Kerckhoff plant west, approximately 52 miles, thence north 14 miles, to Merced, near the north end of the company's existing network, and where interconnection is made with the great system of the Pacific Gas and Electric Co. on the north. During the progress of this work labor shortage was a serious condition, and railway transportation was even more serious. Chief engineer Starr gave the latter considerable of his personal supervision, giving shipments only to the railroad that would not only promise but actually deliver the cars in the least time; and he actually secured deliveries from Chicago in the record time of eleven days and an average time of fifteen days. He accomplished this through connections at Eastern points, by following up personally at this end, and by placing a man on each car coming out. These men reported their location daily, and received instructions as to any necessary immediate arrangements for coming forward.

The railroad delivery point was at Auberry, on the San Joaquin & Eastern Railroad. From here 17 miles of road was constructed, serving the camps and main construction points. All road used by the construction department was built since this job was started. These

roads were entirely in rough mountainous country, with grades as high as 12 per cent and many sharp turns, and soon they became almost impassable on account of the deep dust and ruts. Because of this condition, together with the fact that on account of the dry season the water gave out in the wells at Auberry, a pipe line was laid a distance of approximately five miles from the river along the road between Auberry and the dam site. Pumps were installed to supply water for the camps, and for filling tanks that were placed at night on the trucks, which were used for hauling cement during the day, but served as sprinklers at night, with different forms of drags attached. Inside of a week of thus caring for the roads, they were transformed into boulevards, and were maintained so in spite of the extremely hard usage which followed.

The hauling was accomplished over these roads principally by Mack 5-ton and White 2-ton trucks and a 75-hp. Holt caterpillar with 10-ton and 35-ton trailers of the cross-connected-reach type, under which both axles turn, causing the trailers to "track" around turns (see Figs. 10, 12 and 13). The caterpillar hauled six 10-ton trailers, loaded, in single trains; and as high as 1,000 tons of equipment was transported in seven days' time. The heaviest piece of equipment, which weighed 58,000 lb., was hauled to the power-house incline without difficulty on the special 35-ton Holt trailer with 60-in. diameter wheels, 14-in. tread, the distance of five and one-half miles being made in four

PRINCIPAL EQUIPMENT KERCKHOFF POWER DEVELOPMENT

Equipment	Manufacturers
Turbine, generators and exciters	Allis-Chalmers Mfg. Co.
Butterfly valves	Allis-Chalmers Mfg. Co.
Steel penstocks	Western Pipe and Steel Co.
Penstock rising-stem valves	Joshua Hendy Iron Works
Power transformers	Allis-Chalmers Mfg. Co.
Switchboard and Tirrel regulators	General Electric Co.
110,000-volt switches	Kelman Elec. and Mfg. Co.
110,000-volt switching bushings	Ohio Brass Co.
Taintor gates	California Culvert Co.
Rising-stem sluice gates in dam	Coffin Valve Co.

hours, including loading and unloading. The penstock pipe, in 22-ft. lengths, averaging eight tons per section, was hauled over this road with Mack 5-ton trucks, trailing 2-wheel, 5-ton dollies.

An interesting feature in connection with the study of the topography of the country in which this development was made is the fact that it has been photographed from airplane and a "mosaic" map, Fig. 14, made and checked with the topographic maps made by the company, the results proving so favorable that this method was adopted for accomplishing reconnaissance survey in the Kings River country, in which a development aggregating 500,000 hp. has been started by the San Joaquin Light and Power Corporation.

Mr. Starr, since the Kerckhoff development was about completed, has been engaged in connection with the Kings River development, and also additional work in Crane Valley and Kern River territories. He has purchased a Varney Lincoln-Standard plane with a 150-hp. Hispano-Suiza motor, and by permission of the Air Service and with the personal co-operation of Major H. H. Arnold, in charge of the Air Service, Ninth Corps Area, and other officers of the Air Service at San Francisco, installed a "G. E. M." Eastman Kodak Co. special aërial camera belonging to the War Department. The machine was piloted by Lieut. F. T. Honsinger of the Ninth Corps Area, Air Service, while R. L. Bryant, of the company's engineering organization, operated the camera.

After viewing the country, a map is prepared on which is laid out the areas to be surveyed, and fixed points are established, after which a certain amount of field work is done, establishing triangulation points to be picked up from the air when the pictures are made and to serve as the basis for laying out the air pictures into a "mosaic," on which contours can be sketched in quite accurately; and then study of the possible schemes of development may be made, and of the value of areas for early or late run-off, the location of reservoirs, some of which may be developed from existing glacial lakes, many of which exist in this part of the Sierra Nevada Range at elevations from 10,000 to 12,000 ft.

These air pictures indicate better than anything else the value of each possibility and the capacity to which each may be economically developed.

A note of appreciation necessarily occurs throughout an article of this kind in connection with a project which was started under such extremely unfavorable conditions and a design worked out that has proven to be most conservative, economical, and successful, planned and carried forward to completion in such record time without mishap of any kind and without any regrets, the entire organization working through to the finish in perfect harmony, with the foremen, superintendents, designing engineers, etc., all working in hearty co-operation and with the relation between those at the top and those at the bottom being marked by a firm but just treatment of the men by those in charge, who received in return loyalty and willingness. Contributing considerably to the results there was the earnest co-operation of all the manufacturers in furnishing their equipment in time so as to avoid holding up the work. Early completion of this plant was of vital importance to a vast agricultural territory of the West, which was suffering for lack of water and for lack of power with which to pump it. If this plant merely replaced steam generation and saved fuel, as it does, the completion of it would have been of utmost importance.

Diesel Engine Pointers

If a piston ring fails to bear against the cylinder walls, hammering the inner surface of the ring will increase the diameter of the ring.

In replacing piston rings, a clearance of 0.01 in. between the ring and side of the groove is amply large.

Each piston ring should be fitted to the cylinder, allowing 0.01 in. clearance at the gap.

In many Diesels the top rings gum up very quickly. This may be caused by the kind of lubricating oil used and an excessve amount of it. Often it is the result of low compression pressures, much of the heavier portions of the fuel failing to burn.

If a piston distorts and scores the cylinder, the rough place can be removed by a emery stone or by placing grinding compound on a wooden block shaped to fit the curvature of the cylinder.

In checking the clearance of a piston-pin bearing, place the piston or rod in an upright position, having the rod end free from the floor and the piston suspended from a chain block. If the rod can be swung like a pendulum without tilting the piston, there is ample play. If the rod swings freely, the bearing is too loose.

Steam Making with Fuel Oil

It is generally recognized that it is impossible, in every-day operation of coal-fired boiler plants, to secure results that approach test results where all conditions are as favorable as possible. The same truth applies to oil-fired boiler plants. It is of small practical worth to run a test and then base estimates of operating costs on the test results. If a test is desirable, it should be conducted as nearly as possible under actual operating conditions.

The accompanying table covers the results of a series of tests conducted under such conditions in a mill having two boiler plants. One of the plants contained four Babcock & Wilcox water-tube boilers, each having 9,200 sq.ft. of heating surface. The second plant had seven horizontal-tubular boilers 72 in. x 20 ft. with 70 tubes, 4 in. x 20 ft. each. These boilers had 1,650 sq.ft. of heating surface each.

The men ordinarily in charge of the boilers were left in charge during the tests, and the observing engineers were not permitted to change conditions in any way. The results, then, are as nearly as possible representative of every-day practice.

On the tests the fuel oil was weighed, while the feed water was measured in large calibrated tanks provided with overflows. All pipes not in use were blanked off. The test data were kept in duplicate by the engineers representing the parties interested in the several tests.

The fuel oil was stored in two large tanks supplied with pumps which were driven by steam from the horizontal-tubular boilers. For this reason some of the steam used to heat and pump the oil to the B. & W boilers was supplied by the tubular boilers. For this reason it is necessary to treat the tests by pairs to arrive at the steam used by the oil-burning system. This has been done in the concluding portion of the table.

Consolidating all the tests, the evaporation of water from and at 212 deg. F. per pound of oil was 13.962 lb.

TESTS OF BOILERS USING MEXICAN FUEL-OIL

Date of test	1/9–10/20	1/23–4/20	3/19/20	3/22/20	10/1–2/20	10/8–9/20
Duration, hours	24	24	12	12	24	24
Kind of boilers	B. & W.	Hor. Tub	B. & W.	Hor. Tub	B. & W.	Hor. Tub
No. of boilers	4	7	4	7	4	6
Total heating surface of boilers	9,200	11,550	9,200	11,550	9,200	9,900
Type of burner	Best	Best	Best	Best	1 Hammel 3 Best	Hammel
Pressures:						
Steam gage pressure, lb	120.1	94.5	124.4	101.7	124.0	108.9
Absolute steam pressure, lb	134.9	109.4	139.07	116.6	138.77	123.7
Furnace draft, in	0.32	0.21	0.14	0.18	0.17	0.13
Draft under dam per in	.....	.....	0.54	0.32	0.41	.....
Oil pressure to burners, lb	30	45	19.6	36	40	40
Temperatures:						
Atmospheric, deg. F	37	37	42	58	56	64
Fire room, deg. F	84	80	74	67	74	77
Feed water at boilers, deg. F	174.9	193.8	180.7	201.1	182.1	176.5
Waste heat at dampers, deg. F	486	368	486	464	533	492
Oil to burners, deg. F	183	161.5	180.3	172.3	182	162
Moisture in steam, per cent	1.00	0.67	1.00	0.45	0.60	0.80
Factor of evaporation	1.08	1.0575	1.075	1.051	1.0738	1.0774
Fuel-oil:						
Heat per pound, B.t.u	18,500	18,600	18,320	18,370	18,350	18,370
Weight per gallon at 60 deg. F., lb	8.037	7.978	8.00	8.00	7.984	8.002
Weight of oil used, lb	59,070	103,666	28,403	49,883	68,623	78,020
Gal. of oil at 60 deg. F	7,350	12,994	3,550.4	6,235.4	8,595	9,750
Water:						
Total water fed to boilers, lb	737,788	1,424,388	340,144	707,286	843,036	1,053,027
Total water evaporated, lb	730,410	1,414,892	336,743	704,103	837,978	1,044,603
Water as steam used by fuel-oil system, lb	22,320	58,820	9,220	33,919	21,412	59,573
Net water evaporated and available for the mill's use, lb	708,090	1,356,072	327,723	670,218	816,566	985,030
Total water evaporated from and at 212 deg. F., lb	788,843	1,496,248	361,999	740,012	899,821	1,125,455
Water evaporated per hour per sq.ft. heating surface from and at 212 deg. F., lb	3.57	5.40	3.28	5.34	4.07	5.97
Net water for mill use evaporated from and at 212 deg. F., lb	746,737	1,434,046	352,087	704,398	876,829	1,061,271
Steam made, boiler hp.:						
Rating of boilers in use, hp	920	1,155	920	1,155	920	990
Economic evaporation:						
Gross water evaporated from and at 212 deg. F. per pound of fuel-oil, lb	13.354	14.43	12.745	14.835	13.113	14.425
Net water for mill use evaporated from and at 212 deg. F. per pound of fuel-oil, lb	12.946	13.83	12.396	14.12	12.777	13.602
Efficiencies in the use of fuel-oil:						
Gross efficiency, per cent	70.05	75.08	67.51	78.36	69.35	76.20
Net efficiency, per cent	67.91	72.15	65.66	74.59	67.56	71.85
Combined and weighted results:						
Gal. of fuel-oil at 60 deg. F	20,344		9,785.8		18,345	
Weight of fuel oil, lb	162,736		78,286		146,643	
Heat in a pound of oil, B.t.u	18,564		18,352		18,361	
Total water evaporated from and at 212 deg. F., lb	2,285,091		1,102,011		2,025,276	
Net water for mill use evaporated from and at 212 deg. F., lb	2,180,783		1,056,485		1,938,100	
Steam used by fuel-oil system, per cent	3.77		4.13		4.29	
Gross evaporation from and at 212 deg. F. per pound of fuel-oil, lb	14.042		14.077		13.811	
Net evaporation from and at 212 deg. F. per pound of fuel-oil, lb	13.401		13.495		13.216	
Gross efficiency, per cent	73.40		74.44		72.997	
Net efficiency, per cent	70.05		71.36		69.85	

The percentage of the steam generated which was used to operate the fuel-oil system was 4.04.

No higher efficiencies are ordinarily obtained with fuel oil than prevail in coal-fired plants. The use of oil increases the boiler and setting repairs and therefore interferes with the mill operation to a greater extent than would coal.

The majority of Diesel engines have a compression pressure ranging from 450 to 500 lb. With the ordinary fuel oil ranging from 26 deg. Baumé upward, 450 lb. is ample to ignite the fuel. With a heavier oil which has been topped—that is, has had the lighter oils distilled off—a higher compression may be necessary to ignite the fuel charge.

Economic Value of Coal—II.* Calorific Value and Relative Plant Economy with Coal as Fuel

By B. S. MURPHY
Superintendent of Power, Hudson & Manhattan Railroad

The value of a coal depends not upon its total B.t.u. content, but upon the available heat above a minimum. This minimum is determined by the characteristics of each plant.

THE only reason for using coal under a steam boiler is to convert heat into useful work, so it is of the utmost importance that there is heat available, and, as a general rule, the more heat the better the efficiency in this transformation. Broadly speaking, the heat element in coal is the carbon, and we can expect to get but little more heat from a pound of coal than from a pound of carbon, or, say, 14,500 B.t.u. A pound of fuel contains a varying amount of impurities, depending on the kind of coal, location, method of mining and treatment; and as the major portion of the impurities are incombustible, the greater the quantity in one pound of coal the less the carbon, and consequently the heat in the coal is reduced or the calorific value is lower. Again, as will be taken up later, not only the bulk of these impurities but their characteristics will influence to a great degree the removal of the heat from the carbon or combustible portion, for of necessity, if the carbon for any reason is not consumed, this unconsumed portion is of no more value for heat generation than if it were an incombustible; so any impurity that will prevent the combustion of this carbon will reduce the effective heat value in the boiler furnace.

Laboratory Tests of Coal

It is of primary importance to make laboratory tests for the heat content, but this does not tell us how the fuel will behave under actual furnace conditions. For instance, in an anthracite stoker plant that ordinarily uses No. 3 buckwheat as its regular fuel, the supply became low due to rail congestion, and in order to tide over, a few cars of No. 1 buckwheat were borrowed. The regular No. 3 at that time was running about 10,800 B.t.u. to possibly 10,900 B.t.u. on a wet basis and was not considered very good fuel. The borrowed No. 1 was considered by the owner as an excellent coal for his purpose—being used under marine boilers in river vessels—and had a calorific value of about 12,000 B.t.u. On account of the emergency no special preparation could be made, nor was it really thought of.

The boilers of this station had to be operated at over 200 per cent rating during the peak hour to meet the demand, and of necessity this required very high furnace temperatures. The coal started going to the grates at about the beginning of the peak, first in a few boilers and, as it was being elevated all the while, soon to all of them. The stoker operators lowered their grates somewhat to thin out the fuel bed and shut off a little on their air, but soon the whole surface of the grates was one large fused mass of coke and ashes. More wind was applied, gates shut down still more and hand slicing attempted, but it was of no use. The steam continued to fall, and it was finally necessary to push this clinker off the grates with levelers and build up new fires by hand with soft coal and some No. 3 before conditions were restored to normal. The fireroom crew claimed that the coal had no heat, but on the contrary, it actually contained more than they were used to, with the result that the temperature was so high under the forced conditions that the ash melted and fused. Still this particular coal, as normally used with hand-firing and with normal rating, would have been considered excellent. All this has been discussed to attempt to show that while the determination of the heat content by laboratory means is necessary and that it is safe to insist on high calorific-value coal, this is not the only criterion.

Effective Heat Range

In the discussion of the heating value of coals it is usual to compare the heat contents of the coals directly. This is most fallacious and should be guarded against. It is common to hear in a discussion of the bituminous-coal situation that the coal has fallen off from 14,000 B.t.u. to 13,500 B.t.u., or 3.6 per cent; but when it is attempted to harmonize this 3.6 per cent loss in calorific value with an increase in coal consumption of from 2.5 lb. to 2.8 lb. per kw., something is found to be amiss. Now any such argument as the foregoing is manifestly wrong, for, taking the extreme conditions, coal of 5,000 B.t.u. could not be used to make steam in a power station, as there would not be grate area enough to burn a sufficient quantity to give the heat desired, though this would only be a loss of 64 per cent from 14,000 B.t.u. coal. On the face of it we might consider that if, in place of operating our boilers at 200 per cent, we could tide over with such a coal by possibly getting 90 to 100 per cent rating from them, though from an operating standpoint we know that this is physically impossible. Therefore we must compare coals by their calorific values, not directly, but by the variation through the effective range.

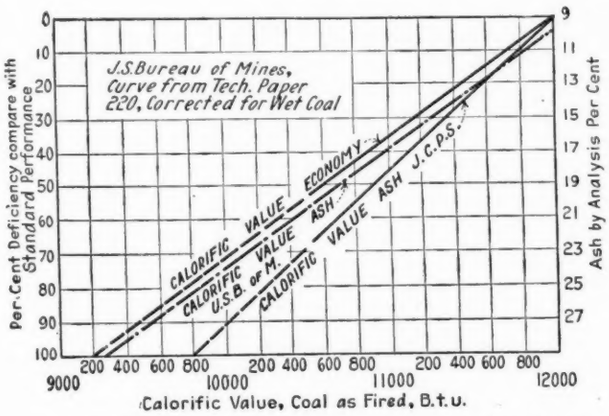
It follows that in any discussion on the relative calorific value of a coal for a particular installation we must first determine the effective range, or the high and low limits of heat content. This will be for the high limit the best coal that we can expect to purchase irrespective of the price, and for the low limit the poorest coal that can be used to get the desired rating from the boiler plant, again irrespective of the price. The high limit must not be influenced by the price per ton, for it may or may not be economical to use the more costly coal. The low limit is more complex; here the location of the plant and existing equipment in the case of an old plant, or the location and the extra first cost of the new one, will be the guides.

In most small industrial plants of, say, 1,000 b.hp. enough boiler capacity is usually installed so that it is

*For first article see *Power*, Dec. 7, 1920.

far from customary to work the units to their limit. In such a case it may be possible to have a rather wide effective range by not forcing the boilers to a high rating. But in modern central stations the boilers are usually expected to be, and the number installed is such that they must be, operated at about their ultimate capacity, with very few spare units, under normal conditions. A very low limit would, then, be out of the question on account of lack of grate surface to burn the additional quantity of coal required.

Again, for new installations, the location would play a very important part in this determination. If the station is to be located where eventually all stations will be, that is, close to the fuel supply, it would be good practice to install enough additional boilers to use the poorer but much cheaper coal. But if the station is in the city, where floor space is extremely valuable and where at least one-half of the first cost of the fuel is freight, then from both a standpoint of capital invested and of operating fuel costs, the effective range will not be as great. It, therefore, simmers down to the fact that every plant must have its own effective range. For existing bituminous electric plants in the East this high limit will be about 14,000 B.t.u.


U.S.Bureau of Mines, Curve from Tech. Paper 220, Corrected for Wet Coal
Per-Cent Deficiency compare with Standard Performance
Ash by Analysis Per Cent
CALORIFIC VALUE — ECONOMY
CALORIFIC VALUE — ASH — U.S.B. of M.
CALORIFIC VALUE — ASH — J.C.P.S.
0 10 20 30 40 50 60 70 80 90 100
9 11 13 15 17 19 21 23 25 27
200 400 600 800 200 400 600 800 200 400 600 800
9000 10000 11000 12000
Calorific Value, Coal as Fired, B.t.u.

CALORIFIC VALUE VS. RELATIVE PLANT ECONOMY

as received and the low limit 11,000 B.t.u., while for stoker-operated anthracite stations the effective range may be considered as extending from 9,000 to 12,000 B.t.u., giving about 3,000 B.t.u. range for each. With smaller, hand-operated plants using hard coal, this low limit is much too low, for as a rule sufficient draft equipment is not available and it is extremely difficult to procure firemen who can or will use this poorer fuel.

Calorific Value of Coal

From a large anthracite station the results of some six years were taken and plotted by months for the pounds of coal per kilowatt-hour against the calorific value of the coal as fired, and though this station had, fortunately, never to use the low limit of 9,000, a prolongation of the curve showed that this tentative figure was essentially correct. Also, plotting the ash or impurities in this same manner against the calorific value showed again that the low limit was about 9,000 B.t.u. In the figure this curve has been given. The "Calorific Value—Economy" curve is an average of the actual results as found, and this extends to 10,600 B.t.u., or the lowest monthly average that was found, though individual coals run considerably lower. The balance, or the dash line, is the prolongation at the same inclination, and this reaches zero at 9,200 B.t.u.

By the relative plant economy is meant the working efficiency of the fuel under discussion when compared with a coal giving standard performance. The curves are drawn showing the relation of the calorific value of a coal and its relative plant economy in terms of the deficiency in the plant economy when compared with standard performance. This deficiency, in other words, represents the additional fuel that must be fired to secure evaporation equal to standard-performance coal.

For example, if the station is such that with 12,000 B.t.u. coal, or 100 per cent standard performance, a kilowatt-hour of output can be produced for 3 lb. of coal, then with another coal containing 10,600 B.t.u. we will find 50 per cent deficiency, or one and one-half times more coal will have to be burned to produce the kilowatt-hour of output; or, as assumed, 3 times 1.5 equals 4.5 lb. per kilowatt-hour. Now if the total-heat-content method was used to compare these two coals, there would only be an apparent loss of 12 per cent, or this coal would have 88 per cent efficiency in heat value, which will be equivalent to a permissible increase of from 3 lb. to 3.36 lb. per kilowatt-hour; but experience will soon show the fallacy of such a calculation.

This curve is extremely valuable with varying grades of coal, as it acts as a check not only on the whole boiler room, but also on the whole power station, for it is essentially correct in its upper end at least. Below 10,000 B.t.u. it really should be modified to meet conditions in each plant, for lack of heat and high ash would be too much for most boiler plants to overcome; but above this it may be used in safety for any ordinary installation. For each station, however, another curve should be made so as to plot the actual consumption per kilowatt-hour against the calorific value based on the station's record of performance.

Calorific Value and Ash Content

The other two lines on the graph give the relation between the calorific value and the ash content as determined by analysis. The line marked "J.C.P.S." has been determined by records extending over six years at the Jersey City power station of the Hudson & Manhattan Railroad Co. This has been plotted for the range of coal encountered there, or from 12,000 B.t.u. to 10,600 B.t.u. by months. This shows how rapidly the calorific value falls off with the greater ash content; the dash-line projection of this curve goes to 9,800 B.t.u. for 29 per cent of ash. They recently had an individual analysis that gave 9,396 B.t.u. as received, and this coal contained 30.7 per cent of ash by analysis, showing that the assumption, arrived at first independently and then by prolongation of a curve plotted from known values, was not far out.

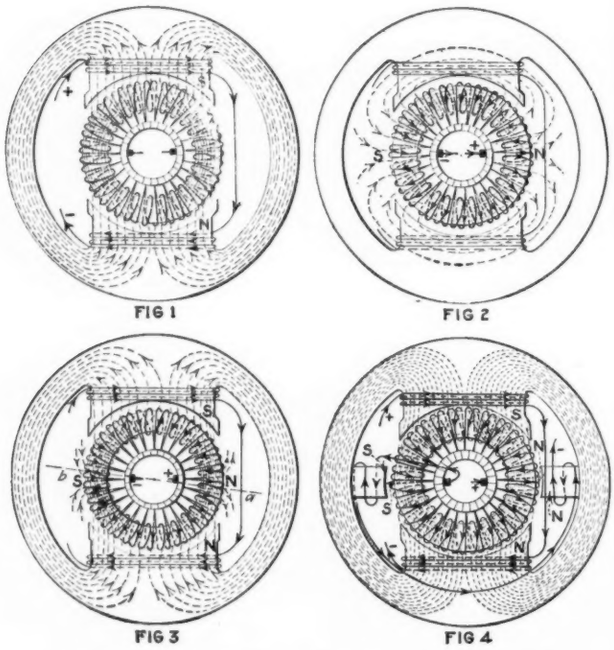
The line marked "U.S.B. of M." has been plotted from data given in the United States Bureau of Mines' technical paper No. 220 in 1919. In this paper the graph was plotted on a dry basis, but to make it comparable with the other data we have converted it to coal as received by taking an average moisture content of 7.25 per cent, which is about a mean value for moisture in No. 3 buckwheat coal. The curve from the Jersey City power station was plotted somewhat before the Bureau of Mines' data was published, and apparently these results show a somewhat more rapid loss in calorific value than the former, but lie very close to one another. It is also very nearly parallel and close to the "Calorific Value—Economy" curve, hence the ash content bears a marked relation to the unit of output.

Direct-Current Motors—Interpole Machines

By B. A. BRIGGS

Distorting of the field from the main poles is caused by the cross-magnetizing effect of the armature poles, and as a result the neutral points are shifted and sparking at the brushes results. This effect can be prevented by the use of interpoles, and connection diagrams are given for series-, shunt- and compound-interpole machines.

IN ALL direct-current machines the armature is an electromagnet with its north and south poles just as the field poles are. Theoretically, the armature poles should be located midway between the polepieces, but owing to the reaction between the two sets of poles



FIGS. 1 TO 4. FLUX DISTRIBUTION IN DIRECT-CURRENT MACHINES

the armature's neutral is caused to shift against the direction of rotation in a motor and with the direction of rotation in a generator. This shifting of the armature's neutral is one of the causes of sparking at the brushes in the simple types of direct-current machines and will be made clear in the following discussion:

In Fig. 1 is shown a schematic diagram of a direct-current machine having a ring-wound armature. If current is sent through the field coils, a magnetic field will be set up which will be uniformly distributed as in the figure. Leaving the field poles dead and passing current through the armature only with the brushes set midway between the polepieces, will cause magnetic poles to be produced in the armature midway between the main poles, as indicated in Fig. 2. The lines of force will be distributed similarly to that shown in the figure. The armature poles are really the resultant of two north and the two south poles. In following the direction of the current through the two halves of the armature winding an *N* and a *S* pole are produced in the upper half of the armature, likewise in the lower half. The *N* poles are produced on the right-hand side and the *S* poles on the left. This brings two like poles together at each brush; these poles repel each other, with the result that the lines of force tend to distribute as in the figure.

Comparing Fig. 1 with Fig. 2, it will be seen that the magnetic field set up by the armature is at right angles to that of the field poles. When current flows through the armature and field coils at the same time, as in Fig. 3, the *N* pole of the armature will repel that of the field poles and attract the *S* pole. Likewise the *S* pole of the armature will repel the main *S* pole and attract the *N* pole, with the result that, instead of the lines of force being uniformly distributed as in Fig. 1, the field will be distorted as in Fig. 3; that is, the lines of force are pushed away from one pole tip over onto the other. This action will vary with the load on the machine. If the load is small, the current in the armature is at a low value, the field poles of the armature will be weak and have very little effect upon the main poles, consequently the line of force from the

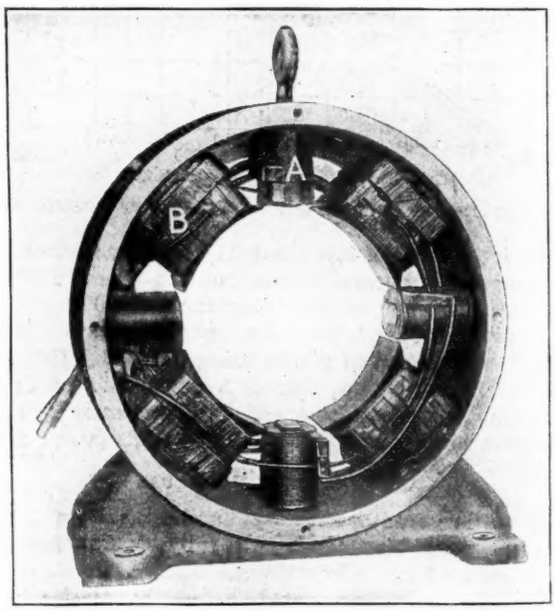


FIG. 5. FIELD FRAME WITH INTERPOLE FOR EACH MAIN POLE

latter will be nearly uniformly distributed, as in Fig. 1. However, as the load comes on, the magnetic field of the armature will increase and its effect to distort the lines of force from the main poles will be increased. Therefore, with a varying load on the motor the distribution of the field from the main poles will be changing. With the flux uniformly distributed, as in Fig. 1, the correct position of the brushes would be as indicated

in the figure, or what is known as the neutral point. When the motor is loaded as in Fig. 3, the neutral point has shifted to some position such as indicated by *ab* due to the distorting effect of the armature poles. Consequently, the correct position of the brushes is not as shown in the figure, but on the line *ab*. From this it is seen that on the simple type of direct-current motor the neutral point shifts with the load, and this is one of the reasons for sparking at the brushes with changing loads on the machine.

To prevent this shifting of the neutral point or to at least hold a magnetic field at this position where the brushes are located, to assist in commutating an additional set of poles is frequently used in modern direct-current machines. These consist of a small pole called an interpole or commutating pole, located in between the main poles with a low-resistance winding connected in series with the armature as in Fig. 4. These poles are magnetized the same polarity as the armature poles, as indicated, and if of the same strength they will neutralize the effect of the armature poles and the neutral will remain in a fixed position. Since they are connected in series with the armature, the strength of their magnetic fields will vary as those of the armature. At light loads the current in the armature and interpole windings will be small, consequently the field poles of each will be weak. As the load increases, the current through the armature and interpole windings increases, likewise the strength of the field poles of both; consequently, if the interpoles are properly designed, they will neutralize the effect of the armature pole at all loads from no load to full load, making it possible to

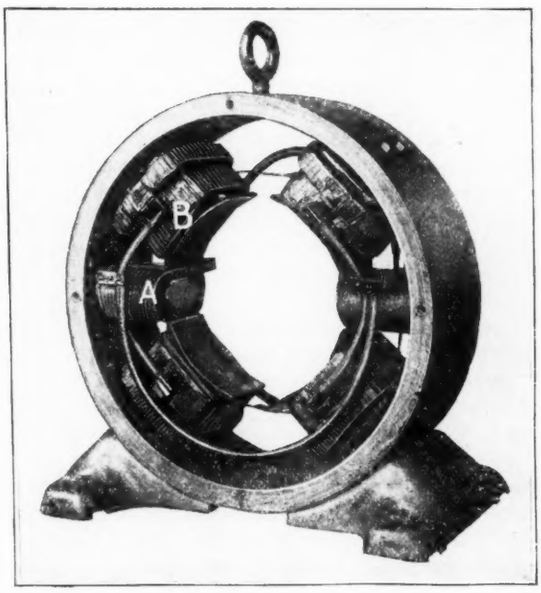


FIG. 6. FIELD FRAME WITH INTERPOLE FOR EACH PAIR OF MAIN POLES

obtain sparkless commutation throughout the whole load range of the motor with the brushes in a fixed position.

An interpole for each main pole in the motor may be used, as in Fig. 5, *B* being the main poles and *A* the interpoles. However, to reduce the cost of construction, sometimes only one interpole is used for each pair of main poles, Fig. 6. In this case it is essential that the interpoles be so located that they are all the same polarity; that is, in Fig. 6 they would either be two north poles or two south poles. But the best practice is to use an interpole for each main pole, and this is adhered to in a large percentage of cases, especially on medium-sized and large motors.

Interpoles are used on all three types of direct-cur-

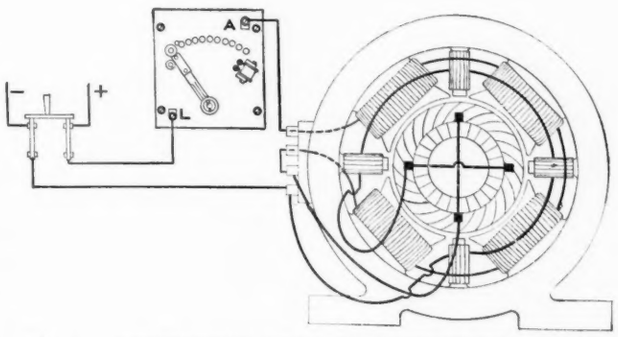


FIG. 7. CONNECTIONS FOR SERIES-INTERPOLE MOTOR TO STARTING BOX

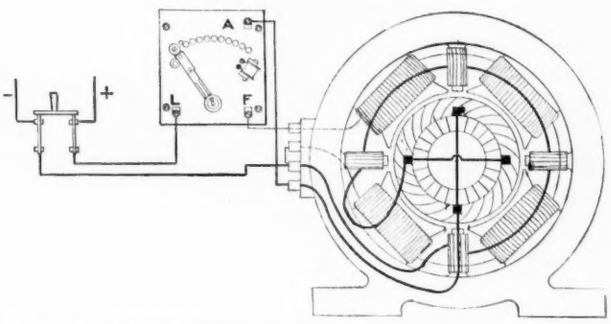
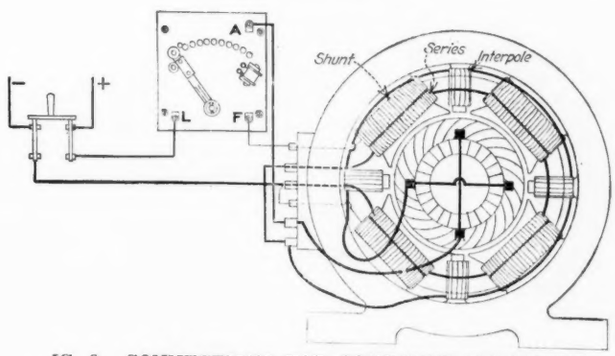


FIG. 8. CONNECTIONS FOR SHUNT-INTERPOLE MOTOR TO STARTING BOX



IG. 9. CONNECTIONS FOR COMPOUND-INTERPOLE MOTOR TO STARTING BOX

nt machines—series, shunt and compound—although as far as the external connections are concerned, the addition of the interpoles to the machine does not in ny way complicate the connections over those for the simple types without interpoles. In Fig. 7 are shown the connections for a four-pole series motor with interpoles, to be started from a manual-type starting box. These are the same as for the simple type of machine. On the shunt-interpole type only four leads are brought outside the motor and the connections to a manual-type starter are made as in Fig. 8. If it was desired to reverse the motor, the connection at the armature terminals would be interchanged, which would reverse the direction of the current through the armature and the interpole windings. This is exactly as it should be,

since if the direction of the current through the armature is reversed, the polarity is reversed, and if the interpoles are to remain the same polarity as the armature, the current through this winding must also be reversed.

In the compound-wound interpole machine the interpole winding is connected in the circuit between the armature and series winding. The connections to a manual-type starter are given in Fig. 9. It will be seen that, externally, these are the same as for a compound machine without interpoles. To reverse the direction of rotation of the motor, all that is necessary is to interchange the conections on the interpole and armature terminals outside the machine. This will reverse the direction of the current through the armature and interpole windings as in the shunt machine. From the foregoing it is evident that the connections of interpole machines to their starting device are the same as for those without interpoles.

(The next article will discuss the compensated type of direct-current machines.)

The Pressure Injection and the Air Injection Oil Engines

By Hermann Shultz

It is indeed surprising, in view of the wonderful strides that have been taken in Europe in the development of the Diesel motor, to discover the amount of experimenting being given to the principle of pressure injection in England and America. In using the term pressure injections, the writer intends it to cover all designs of the internal-combustion oil motor where the oil is introduced into the working cylinder without the employment of injection air and with the aid of a pump. As has been stated, it is surprising, in fact rather bewildering, to see the attempts made to secure Diesel-motor efficiency with pressure injection. In truth one is compelled to speculate more or less if the designers of these latter types of motors really understood the process of combustion occurring in the cylinder of the gas motor, or rather, oil engine. Surely if the processes of vaporization or gasification, ignition and combustion were fully appreciated, hope that the pressure injection or, as the Americans term it, solid injection would show an economy anyways near the Diesel motor would vanish.

It is no great achievement to design a pump that will force the oil fuels into the engine cylinder; nor, even if introduced most inefficiently, will the oil drops refuse to burn—although uneconomically. But to expect that this combustion is other than inefficient is too much.

Fuel Introduction

In considering any method of introducing the fuel oils into the engine, due study must be made of the processes going on during the spraying, and after the introduction has been accomplished. The fuel, whether it is paraffin, tar oil or one of the many oils that lie between these two in complexity of compound, must be introduced into the cylinder, next it must be gasified, then ignited, and finally complete combustion must take place.

With the usual injection of the Diesel motor the oil is broken up into drops averaging $\frac{1}{100}$ mm. (0.00039 in.) in diameter. These minute particles must be gasified and mixed with the correct amount of air to secure combustion. If these particles could remain in the cylinder indefinitely, complete gasification and union with the oxygen would take place, regardless of size of particles. The time interval of combustion is small. The length of time required for gasification and combustion depends, then, on the degree of separation that takes place during injection. If the drops are large, the gasification is but partly accomplished by the time self ignition in some parts of the gas vapors begins. The result is that the gasification is not complete when the normal period of combustion ends; the natural result is that the combustion continues along the entire power stroke—in fact, usually continues in the exhaust lines.

Fuel Atomization

In the design of the Diesel motor spray-valve modifications in the shape of the atomizing discs, etc., affect to a considerable extent the degree of fineness into which the oil is broken in entering the cylinder. It should be understood that the breaking up does not occur in the fuel valve. Here the air and oil are mixed, but the oil cannot be said to be separated into small particles until it enters the cylinder. The force of the blast air as it expands from 70 to 30 atmospheres effectually breaks up the oil into very minute particles. The inrush of the injection air gives rise to a turbulence of the air compressed in the combustion chamber; this whortling mixes the oil particles with the air, affording a very complete union. The air blast performs a greater service in the combustion chamber than in the spray valve. The amount of fuel injected into the cylinder has no effect on the process of combustion since the air blast effectually breaks up and mixes the low load charge as well as it does the full load charge.

Turning now to the pressure injection such as the Vickers, this engine uses an exceedingly heavy pump pressure to inject the oil into the cylinder. To maintain a rate of oil introduction equal to the Diesel motors, the opening in the flame plate must be made small—at about a ratio of 25 to 1, since no injection air is present to increase the volume. The smallness of this opening necessitates a high pump pressure of about 12,000 to 16,000 lb. per sq.in. It is difficult to keep up equipment with such pressures.

Cylinder Pressures

The plan is to use the high velocity of the oil to break it up. If this was possibly to do effectually, it would follow that the larger the cylinder the better would be the mixing. To the contrary, it has been the practice of these builders to keep the cylinder dimensions fairly small. A more important feature of the action of this type of injection is the high maximum pressures occurring at the moment of fuel admission. Frequently, the indicator cards show pressures several atmospheres higher than is usual in Diesel motors. Again, with heavy introductions of fuel, such as at full load, the pressure-injection engine smokes badly. During the war this was the chief criticism against the design. This feature is to be expected from a consideration of the events occurring in the cylinder. The spray of oil as it leaves the fuel valve cannot come into contact with the entire air charge in the cylinder. The direction of the spray must be toward a rather localized area. There is no expansive force to cause diffusion other than what might be termed the non-cohesiveness of the liquid. On low loads, then, most of the oil is fairly well broken up and gasified. On heavy loads only the outer portions are

broken up, while the interior is fairly solid. This portion gasifies, but in so doing also goes through a chemical process, so-called "cracking," depositing some of the heavy hydrocarbons, since the gasification is slow and is not completed when ignition of the outer oil vapor starts. At the high temperature of combustion "cracking" always takes place. The engine then smokes on full load. That this inefficiency with heavy fuel charges is due to insufficient mixing of oil and air is proved by the clearness of the exhaust on light loads and the fairly sustained fuel consumption per brake horsepower on low loads notwithstanding the mechanical loss is constant.

The Vickers engine has a needle valve as is common with the true Diesel. The only elimination is the absence of the air compressor. The complication of the fuel-pumping mechanism more than offsets the advantage of the elimination of the compressor. In fact, it can hardly be denied that the engine is made more complex.

A number of engine builders have taken up the pressure injection without the use of a controlled fuel valve. This is, of course, but an improvement of the hot-ball engines such as the Bolinders and Petter, which have had pump fuel-injection systems from the first. That the pump method is fairly good for small engines cannot be denied if low efficiency is not objectionable. Some builders, notably Crossley & Co., realize the danger of defective mixing, so attempt to elongate the combustion chamber to give a greater spread to the oil jet. To obtain part of the turbulence achieved by the Diesel air blast, this concern makes the piston end cone shape, expecting the air rushing up along the cone to give a turbulence effect.

American Designs

Certain of the American engine builders have adopted the pump system, using two jets of oil. The design contemplates air turbulence being secured by the interference of the two sprays. On full load the body of the fuel gasifies slowly and "after-burning" occurs. On low loads the fuel mixture is better; so much so that if the air suction is not throttled to reduce the air charge and to retain some of the burnt gases from the previous explosions, violent preignition takes place. The early timing of the fuel admission, about 40 deg. early, often causes excessive pressures. It is by no means uncommon to observe pressures above 50 atmospheres. The excellent efficiencies shown by some of these engines on test are undoubtedly secured with a maximum explosive pressure well above 800 lb. In fact, it has been stated by at least one engine builder that the greatest difficulty was experienced in keeping the pressure within limits.

The action of a pump is by no means as rapid as a needle valve. The cessation of the oil spray into the cylinder is necessarily slow, and the lines may continue to leak.

The high pressures that occur preclude any lightening of the weight of the engine. Indeed the engine should be heavier. The air compressor is, of course, eliminated, but the pressures on the fuel pumps are so high that serious trouble will surely occur.

To an impartial person the conclusion is obvious. For small powers, probably 75 hp. per cylinder, the pressure injection, or the solid injection, as Americans call it, offers certain advantages where fuel consumption is not of primary importance. In large units the results obtained do not warrant claims of superiority over or even equality with the Diesel. Too many foreign firms, especially American and English, attempt to effect sales by building engines with radical features or unusual mechanism. No stress is made on the superiority of workmanship, to which feature the success of German Diesel builders is largely due.

Refrigeration Troubles

By Roland L. Tullis

A sudden drop of the suction or condenser pressure of an ammonia compression system is indicative of some sort of trouble, and the cause should be searched for immediately. If the plant is equipped with double-pipe brine coolers, the trouble may be caused by the brine-circulating pump losing its suction; or if the brine is circulated by a motor-driven pump, it may have blown a fuse and stopped. Stoppage of brine circulation in the coils naturally lowers the rate of ammonia vaporization, and the suction and condenser pressure will drop immediately. If the brine circulation is stopped for any length of time, the coils are liable to freeze up, the suction- and discharge-gas temperature will drop and the suction line will be likely to frost back more than usual.

An experienced operating engineer, by watching his gages and suction and discharge temperature, can tell pretty nearly whether the plant is operating properly or not. Good brine circulation through the coils is essential to economical operation.

The writer was once employed in a refrigeration plant which contained a number of double-pipe brine-cooling coils. One day one of the shift engineers rushed up to the chief and explained that the system was short of ammonia. The receiver was empty, temperatures were going up and the suction and condenser pressures gradually diminishing. The chief glanced at the gages, examined the receiver (which sure enough was empty) and shook his head. There had been plenty of ammonia a few hours previously, but somehow it had mysteriously disappeared. Then he happened to remember that early that morning they had cut one large brine cooler out of service. He remembered having ordered one of the helpers to close the stop valve and expansion valve on the coil.

Upon examination it was found that the stop valve was closed tight, but the expansion valve was only partly closed. In consequence practically the entire ammonia charge had leaked into the coil, where it was trapped. In such a case care must be exercised in opening the stop valve, as a slug of liquid may be thrown back into the compressor suction.

I know of a case where the operating engineer was attempting to pump the liquid out of an ice-cream hardening room. He had forgotten about the expansion valves being open, and the room temperature had dropped to between 15 and 20 deg. below zero. Then, when he shut off the expansion valves and attempted to pump the liquid out, the suction pressure naturally decreased and the temperature continued to drop. The more he pumped the lower the pressure dropped, and the temperature went down correspondingly; the liquid refused to vaporize on account of the low temperature. The engineer was having a time to get the liquid out of the coils and back into the receiver, where it belonged. Finally, he hit upon a bright idea, but it proved disastrous;

he opened the gate valve on an auxiliary line which connected with the suction of two large compressors. This threw a 22-lb. back-pressure from the big machines down into the hardening rooms. This brought the liquid out in a hurry, resulting in loosening the heads on two compressors and nearly knocking them off the foundation.

After all this is said and done, handling ammonia liquid or gas is somewhat of a tricky proposition. It requires experience, study and good judgment to handle it successfully.

The Protection of Motor Windings

By Gordon Fox

In his article "Treatment of Direct Current Motors for Mining Conditions," which appeared in the Oct. 12 issue of *Power*, Mr. Arnold mentions the importance of keeping armatures and field coils well varnished. This cannot be too well emphasized. The cotton and other insulations commonly used in the make-up of coils serve largely as mechanical separators and as a medium for absorbing the varnish. The varnish acts as an insulator, a heat conductor, a binder and a protecting medium.

There are many qualities of varnish. So called "air-drying" varnish is most easily applied, but is less elastic and tends to crack and chip in time. Elasticity is important in maintaining a continuous covering without cracks and crevices in which dirt and moisture may lodge. Baking varnishes have greater elasticity and are more effective. Clear baking varnish is the best, but is slow-drying and hardest to apply. The slower-drying the varnish the better the ultimate job.

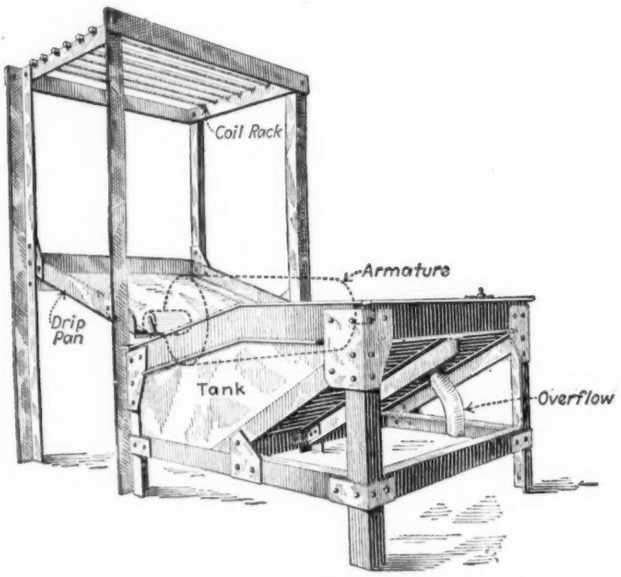


FIG. 1. INSULATING COMPOUND DIPPING TANK

The dipping tank shown by Mr. Arnold has many commendable features. Another type of tank used for dipping armatures and all kinds of coils is shown in Fig. 1. By adjusting the stop pins in the sloping upper edge, any size armature may be allowed to be submerged at the coils, yet the commutator and shaft are kept clean. A paper is wrapped about the commutator to keep off any drip. The armature is rotated slowly to submerge all the coils in the varnish. It is then rolled up the incline and allowed to drain while resting on the upper horizontal portion. A movable cross-member having a similar incline may be inserted for use with armatures having short shafts. A separate coil-drying rack can be moved in front of the tank so as to drain into it. Covers are provided to prevent excessive evaporation of the varnish in the tank. This equipment has proved very satisfactory in service.

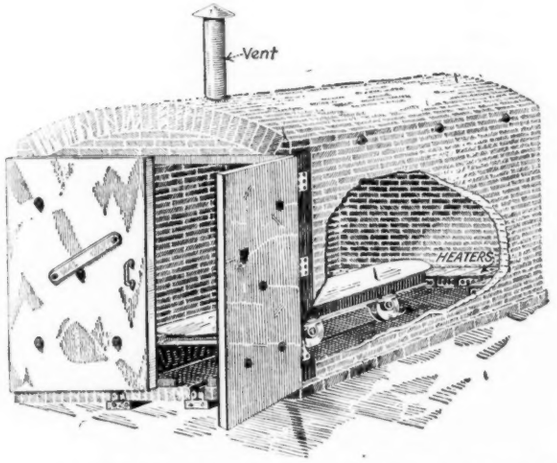


FIG. 2. OVEN FOR BAKING COILS AND ARMATURES

A small, brick drying oven is shown in Fig. 2. This is arranged to house a small car, which is rolled in after loading outside. The car is arranged to carry two large armatures, and a removable rack for coils may be attached to it. The oven is heated by grid resistors, several connections being afforded to govern the temperature. Openings are left at the bottom of the oven behind the grids for entry of air. The heated air passes out a small stack. A pipe inserted in the arch carries a thermometer for indicating the oven temperature. The doors are made up of angle frame covered with sheet steel on both sides, the space being filled with loose asbestos. The whole arrangement has worked out very well.

Dirt and moisture cause a very considerable proportion of motor failures. While varnish affords a measure of protection, dirt and moisture should be excluded from motors so far as possible. Totally inclosed motors such as mill-type and mine-type machines are more expensive in first cost, but their better service will usually justify the investment where unfavorable conditions must be met. Open-type motors should be provided with solid inclosing covers on the upper openings when located in dirty places. A little more heating is usually much less harmful than dirt. It must be realized that when coils are covered with dirt and ventilating slots are plugged, radiation of heat is not very effective.

It seldom pays to experiment with different engine oils. After a suitable lubricating oil is secured, continue to use it. All reputable refineries make Diesel lubricating oils that can be safely used. Some refineries have had much experience in the oil-engine field and can supply oil suitable for each particular make of engine.

Refrigeration Study Course—XIX Applications of Refrigeration

By H. J. MACINTIRE
Professor of Refrigeration, University of Illinois, Urbana, Ill.

SOME thirty years ago mechanical refrigeration was used mainly in the brewery industry, but of late years the great advance, first of ice making, and then of cold storage (including the packing-house industry) had relegated the brewing total tonnage—even before the advent of adverse legislation—to secondary importance. However, there is now hardly any branch of engineering that is developing with the speed of refrigeration in variety of application and in the amount of sales. The chemical industries are paying more and more heed to the latent possibilities of mechanical cooling in their processes, as are also the engineers in almost every branch of work. The steel mill uses refrigeration in tempering and hardening, the oil refinery in separating out the paraffin, the oil and natural gas men utilize refrigeration to some extent in separating out the gasoline. The chemical industry, the baker, the candy maker and the miner use refrigeration to secure standard conditions—a cold water, cold air or a cold strata of earth. As an example of the extremity to which the industry is carried, it may be mentioned that the Haber process for fixation of atmospheric nitrogen is to form ammonia in a mixture of hydrogen and nitrogen by means of a special catalyst, and then to freeze the mixture to —20 deg. F. or lower until the ammonia is liquefied and separation may be secured by means of gravity and a modified trap. In making an analysis of the different kinds of applications of refrigeration, one will be surprised at their similarity. As just noted, it is nearly always the matter of the cooling of a fluid, liquid or a gas, which in turn does the work desired of it. However, there are a few other special applications which, because of their general use, are worthy of special mention. A few of these will be taken up in turn.

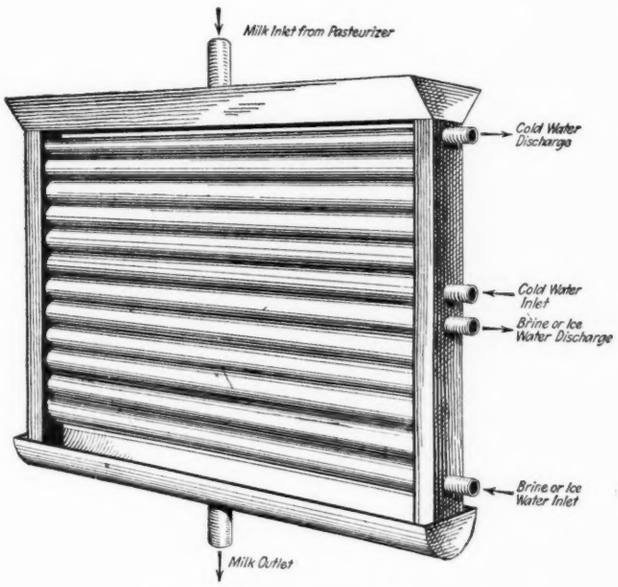


FIG. 1. THE BAUDALOT COOLER

The milk industry is an important one. It is a daily necessity, a food that cannot be dispensed with. In consequence of the distance from the source of supply the city milk trade is subject to a delay so that by the time it is ready to be served the milk may be 36 to 48 hours old. The result is that raw milk is frequently badly contaminated with bacilli of intestinal or lung variety, especially if the temperature of the milk is allowed to remain even for a short time at a temperature 60 or more deg. F. So to reduce the danger from disease the pasteurizing process has been perfected. This consists of either bringing up the milk temperature to 140 to 150 deg. F. and holding at that temperature for thirty minutes (the preferred method) or of raising the temperature to 160 to 165 deg. F. and maintaining this temperature for only one-half to one minute. After the pasteurizing process the temperature should be reduced to 35 to 45 deg. F. as quickly as it is practical. This cooling may be accomplished in either of two ways—first, by means of a regenerative apparatus, and second, by means of the old-style Baudalot cooler.

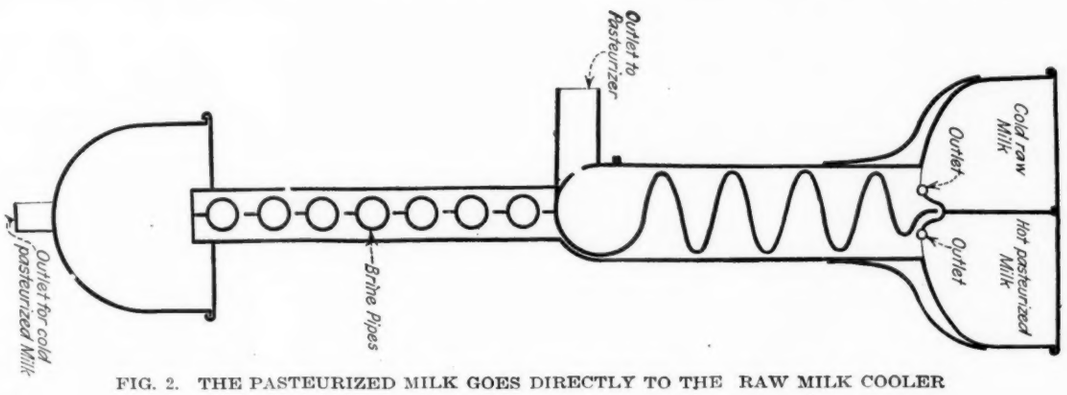


FIG. 2. THE PASTEURIZED MILK GOES DIRECTLY TO THE RAW MILK COOLER

Assuming that the milk leaves the pasteurizer at about 140 deg. F., it would be sent to the regenerator as shown in one design by Fig. 1. The regenerator is a sort of counterflow exchanger. The raw milk is relatively cold and must be heated to 140 deg. F., and the pasteurized milk is at 140 deg. F. and must be cooled. By using a counter-current device, both of these may be accomplished easily and cheaply. The last portion of the work of cooling is by means of brine, reduced in temperature by means that are usual in mechanical refrigeration.

The second method is to pipe the pasteurized milk directly into the cooler. This cooler is usually made of block tin (for cleanliness) and is arranged so that the milk flows on the outside, being cooled first with water and then by brine. The refrigerating problem is a simple one, requiring brine of about 20 to 25 deg. F. The most important point is that the milk cooling after pasteurizing makes a heavy load, usually for a short part of the day only. It usually works out best to have a brine-storage tank of sufficient size to carry a large part of the load. In so doing the compressor may operate over a longer period of the day, and the machine may be a small one. The amount of refrigeration stored in the brine depends on the temperature rise of the brine. Assuming this to be 20 deg. F., the brine storage necessary to cool 1,000 gal. of milk from 80 to 40 deg. F. would be

$$\underset{\text{number gallons}}{1000} \times \underset{\text{lb. per gallon}}{8.58} \times \underset{\text{temp. range}}{40} \times \underset{\text{specific heat}}{0.9} = \text{vol.} \times \underset{\text{weight of cubic foot}}{62.5} \times$$

$$1.2 \times \underset{\text{specific heat}}{0.7} + \underset{\text{temp. range}}{20} = 294 \text{ cu.ft.}$$

Ice Cream Making

In ice making there is required frequently from 1.4 to 1.7 tons of refrigeration for 24 hours to produce a ton of ice. In other words, much more refrigeration has to be put into the manufacture of ice than it is possible to secure in cooling effect by the melting of the ice after it is made. The reason is that in ice making the water has to be cooled first to 32 deg. F., then frozen, and finally the ice cooled down to somewhere near the brine temperature. All this require (assuming 70 deg. water)

$$(70 - 32) + 144 + \frac{32 - 14}{2} = 191 \textit{ B.t.u. per lb. of ice.}$$

To this should be added the losses by radiation, conduction, etc., and the meltage and other losses in removing the ice from the cans and storing the cake in the storage rooms. The total input in heat units per pound net of ice is therefore from 210 to 230 B.t.u., from which only about 144 B.t.u. is usually available for refrigerating purposes. In ice making, therefore, it is necessary to cool the water, freeze the ice and finally cool the ice.

Ice-cream making is about the same kind of refrigerating work. About the only difference between ice making and ice-cream making is in the details of the operation. Ice cream, of course, is not frozen in a mold like can ice, but as a rather soft mush, after which it is placed in a container and allowed to cool to a solid condition in the hardening room. The refrigeration problem in ice-cream making is in the cooling of the cream, freezing into a plastic condition, and finally the hardening process, which is much like the cooling of can ice down to the temperature of the brine in the ice tank.

Calculations for the duty required are not as positive as in ice making, because the latent heat of fusion of the mixture of cream and the specific heat before and after freezing are not constant for all kinds of ice cream or ices. In general the mixture is usually placed in the freezer at about 50 deg. F. and the whipping of the cream is at about 26 deg. During the process of freezing the cream "swells" an amount from 50 to 100 per cent, although the amount is usually about 80 per cent. Using the latent heat of ice cream as 84 B.t.u. and the specific heat before and after freezing as 0.68

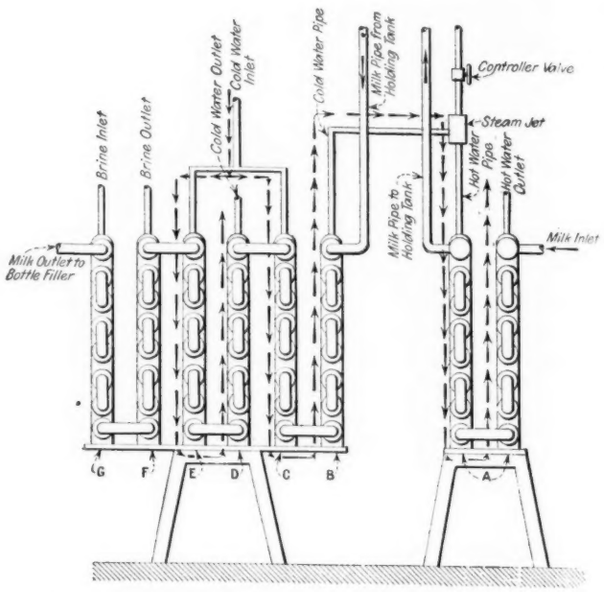


FIG. 3. DOUBLE-PIPE PASTEURIZER AND COOLER
Follow course of water and brine through the coils A, B, C, D, E, F and G.

and 0.38 respectively, the refrigeration necessary to make 100 gal. of cream from a mixture at 50 deg. F. and cream at 0 deg. F. would be:

$$\frac{100}{1.8} \times 8\tfrac{1}{4} \times 1.2 = 556 \textit{ lb. (weight of cream to be frozen}^1\textit{)}$$

$$\underset{\text{(Weight}}{(556} \times \underset{\text{specific heat}}{0.68} \times \underset{\text{temp. range}}{50 - 26}) + \underset{\text{(weight}}{(556} \times \underset{\text{latent heat of fusion}}{84}) +$$

$$\underset{\text{(weight}}{(556} \times \underset{\text{specific heat}}{0.38} \times \underset{\text{temp. range}}{26 - 0}) = 61{,}271 \text{ B.t.u.}$$

If, for example, this work was to be done in one hour, there would be required 61,260 ÷ 12,000 = 5.1 tons capacity. Of course there are the usual leakage losses to be taken into account as well as the ice for icing the deliveries and other incidentals still to be considered.

Mechanical efficiency is a term intended to express the ratio of indicated horsepower to that available for doing work. Brake horsepower divided by indicated horsepower gives the mechanical efficiency. For four-stroke-cycle Diesel engines the mechanical efficiency may be as high as 80 per cent or as low as 70 per cent of the indicated power. For two-stroke-cycle engines the mechanical efficiency is sometimes as high as 80 per cent of the indicated power.

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[1]Weight of cream depends on the swell and the specific gravity of the mixture.

How to Cut Belts Square

Although many articles relating to belt lacing, etc., have been published in *Power*, the instructions prepared by F. D. Rich for the Crescent Belt Fastener Co. contain some interesting information, which is published in part herewith.

Cutting the ends of a belt to put it into service seems such a simple thing that often the belt man does not give it the consideration necessary to insure the best results, and much of the difficulty with otherwise good belts is due to their not being cut and joined accurately. When one knows how, it is as easy to make a belt joint that will run the same as an endless one as it is to do it by careless rule-of-thumb methods. When a belt runs "wabbly" or races back and forth across the pulleys, it is not giving its best service nor can it have its longest life. If its ends are cut square and it is joined with care, it can be made to run as straight as an arrow if the pulleys are lined up true.

Don't guess at cutting your belt ends. Use a square always, and use it with care. If you do not use a square, one or both ends will be cut unevenly or irregularly, which prevents smooth running. Even the use of a straightedge does not assure the perfect results obtained by using a square, for the slip of a fraction of an inch will bring the belt ends together at an angle, as shown in Fig. 1.

This results in the belt "shimmying" on the pulleys, which is bad for the belt and impairs its service, for as it moves from side to side the line of direct pull *AB* moves from one side of the belt to the other, imposing shifting and irregular strains, which no belt can stand indefinitely.

There is only one way to assure correct results. That is to use a belt square and to keep it in place until you have cut all the way through the belt. Don't just scratch the surface and then hack through. Cutting to the square assures an even cut all the way through the belt and all the way across. It means that the ends can be brought together in a tight, butt, evenly running, flush joint.

For belts up to 15 or 18 in. wide an ordinary square may be used. Press it firmly against the edge of the belt and, when cutting, hold the knife vertically, as shown by Fig. 2.

Be sure your knife is sharp. Wet its point occasionally, as it cuts more easily when the blade is wet.

When a number of belts have to be cut, a good stunt is to drive two nails in a large block of wood, and against these set the edge of the belt and the edge of the square, as shown in Fig. 3. This prevents either the belt or the square from slipping. Some men tack a slip of leather or a piece of old belt on the end of the block to protect the point of the knife as it comes through the belt.

Wide belts are harder to square correctly, and the difficulty is often increased by slight variations in the width, which throws the square out. To avoid this and assure perfect results, the following method has proved the best.

At any point near where you are going to cut the belt, measure across and find the center, as at *AA*, Fig. 4. At any distance back of this, say two or three feet, find the center again, as at *BB*. Between these two center points draw a clean, sharp line. This marks the center axis of the belt. Then, as shown by Fig. 5, using the square against the center line, trim off the end of the belt, holding the square firmly in position while you cut all the way through. Two small nails driven in on the center line will keep the square from slipping.

For cutting the other end of the belt find the center line as just described. Then, at any point on this line other than where your belt clamps will come, take a point *C*, as in Fig. 5, and using the square as illustrated, draw a line *DCE* at right angles to the axis and all the way across from edge to edge. It is sometimes easier to draw this line by marking the points *D* and *E* and then placing a straightedge through the points *D*, *C* and *E* (see Fig. 6). Be sure that the straightedge *is straight*, not warped. This line *DCE* will

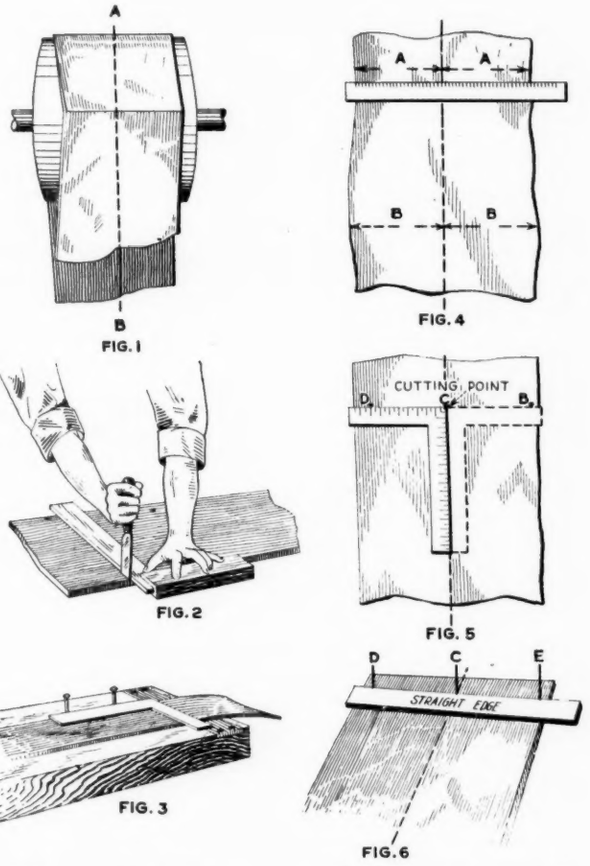


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6

FIGS. 1 TO 6. DETAILS FOR CUTTING BELTS SQUARE

Fig. 1—A belt joined this way cannot run true. Fig. 2—Hold square tightly against the edge and cut all the way through the belt. Fig. 3—Simple "stunt" makes square cutting easy and positive. Fig. 4—Finding the center by measuring in from the edges of the belt. Fig. 5—Using square from the center line. Fig. 6—On wide belts use a straightedge when a large square is not at hand.

constitute a "base line" to measure from after the belt is in the clamps. Do not cut on this line.

You can determine exactly where you want to cut after the clamps have been put on and the belt brought into position. Then measure forward from the line *DE* an equal distance on each side of the belt to the cutting point. You can use calipers and measure over the belt clamp or run your ruler through the edges of the clamp. As a matter of convenience always cut one end of the belt square and get it ready for making the joint before putting the belt into the clamp. Regardless of whatever method of joint is used, the belt should always be cut square, so that it may exert a straight-line pull.

Willis Lawrence

The Man Who Is Responsible for Generation of the Power That Drives Most of New York's Transit Facilities

RUSHING along at forty miles an hour on the subway trains of the Interborough Rapid Transit Co., one's thoughts quite easily turn to the source of all this power—to the great machines that produce it and the men that guide and control it. That is Willis Lawrence's job—the operation and maintenance of all the power houses in the Interborough system of subway and elevated lines and the four New York Railway power stations, which drive the surface cars. Like most men who have developed the ability to "get things done," his beginning in life was comparatively humble, though he is a descendant of Revolutionary and Puritan forbears. He was born in 1868 at the old Lawrence home in Cold Springs, N. Y. He went through the public schools with the intention of later attending Cornell, but a desire for practical experience, coupled with limited finances, caused him, instead, to go to work on neighboring farms. After the young man had been at this work for five years his opportunity came, and he was not slow in grasping it. Learning that a large stone-crushing plant was to be built at Storm King, two miles from his native village, he went to the contractors and began his engineering career by taking a job with them as a laborer. His natural mechanical ability was recognized here, and he was made oiler, machinist, engineer and finally foreman of repairs. Later, he refused the position of chief engineer and went to Weehawken, N. J., in 1890, to assist in the construction of another large crusher plant, of which he became chief engineer when it was completed. In 1894, the ice making field seeming to offer big possibilities, Mr. Lawrence went with the New York Ice Co., which was at that time remodeling one of its ice stations at East One Hundred Sixteenth Street. Here he was appointed assistant engineer, and when the plant went into operation in the early summer, he was made chief engineer. Late in 1898 he was transferred to the East Eighteenth Street plant to remodel it and take charge as soon as it was in operation. He remained in this position until January, 1902, when he began his career in the railway power houses. At this time, it will be remembered, important developments were being made in the design of power houses. Edwin Reynolds had some time before been hurriedly called upon by the Interborough Rapid Transit Co. to design for it the engines which will forever remain famous, not only as the Manhattan type, but as those which, like the giant redwoods of California, were the last of their kind. Here, in this new field, in a plant where all the great advances in the power-house art were being for the first time applied, Mr. Lawrence was employed as a machinist and assistant operating engineer. One gets an idea of how he must have fitted into the scheme of things from the fact that, after but a year on this job, he was made first assistant mechanical engineer. In May, 1904, he was made mechanical engineer; three years later he was given the position of mechanical engineer of both the Manhattan power houses and the subway power house, and in March, 1912, he became mechanical engineer of the Manhattan and Subway Division and the New York R.R. power stations. The latter consisted of the Ninety-Sixth Street and the Houston Street and Lexington Avenue power houses. It is a tribute to the man's ability that back in 1914 when these great 12,000-hp. Manhattan-type reciprocating engines, after 18 years of hard operation, were to be discarded and replaced by turbines, they were found to be in really better mechanical condition than a year after they were installed.

WILLIS LAWRENCE

While economical performance is largely a matter of design, it must be remembered that attention to operation and to maintenance plays its part. This work was up to Lawrence, and his success in handling it is perhaps best attested by the fact that for economical performance the combined reciprocating-engine low-pressure units at the Fifty-Ninth Street power house long stood unequaled.

EDITORIALS

A Western Achievement

AT THIS time, when so much attention is being centered upon the development of our water powers, the leading article in this issue, "Kerckhoff Power Development—a Western Achievement," is of particular interest. Although in size this undertaking does not rank with many others made in various part of the country, when measured in the period required to complete the work and the difficulties encountered, it is easily entitled to a place alongside our foremost hydro-electric engineering achievements. It is one thing to build a plant in a region accessible by railway and good highways and an entirely different undertaking in a rugged mountainous country seventeen miles from the nearest railroad and requiring the construction and maintenance of highways for the transportation of all materials and equipment. In the East we have become accustomed to thinking of hydro-electric plants being built where there is an actual waterfall. On the Pacific, although falls do exist, many of the sites for such plants are only rapids in the river. A dam is built near the head of the rapids and an open ditch or tunnel run from above the dam to a point down the river where the most economical head is obtained. The Kerckhoff power plant is one of these developments, and required the construction of not only a dam, but also a tunnel eighteen feet square and over three miles long, cut in solid granite.

Although the generators and turbines to a large degree conform to what may be considered standard practice, the waterwheel-driven exciters without a governor and mounting a compound-wound generator on the exciter shaft to supply current for operating oil switches, et cetera, are a departure from the standard. It is well known that the load on an exciter is practically constant, and as a result the wear on the governor parts is only within a very small part of the load range, and if the governor is called upon to meet an emergency, it is very likely to fail. An attempt in the Kerckhoff plant has been made to overcome this by putting the exciter's waterwheels directly under the control of the operator and by designing the exciters so that they will have a tendency to load up the waterwheel at excessive speeds. Making the source of control current independent of the exciter, although driven by the same turbine, allows the selection of the most efficient voltage for excitation and also for the control circuits. It also insures current being available to operate switches, et cetera, in an emergency where the exciter may fail.

One feature that stands out very prominently in making the efficiency tests on this plant is the vast amount of preparation necessary. When it is considered that at the present time machines of three times the capacity of the Kerckhoff machines are under construction, to operate under a somewhat lower head, it is evident there is a pressing need for some simpler means of making tests on hydraulic turbines. Fortunately, a device is already far enough along in its development to indicate that in the near future the testing of hydraulic turbines will be a comparatively simple operation.

An interesting feature in connection with the study of the topography of the country in which this power site is located was the use of an airplane. This was the first time an airplane had been used for such work, and it was so successful that it is now being employed in reconnaissance survey work in other power projects. Apparently, in the not distant future, such surveys will be considered an important part of hydraulic developments, especially in mountainous districts that are difficult of access.

What is the Present Equivalent of $2,500 in 1848?

THE salaries of the examiners in the United States Patent Office were fixed in 1848 at $2,500 per year. At that time this was a good salary. It was as much as a member of Congress or a United States District Judge got, and one-half as much as was paid to the Chief Justice of the Supreme Court. Today the justice receives $15,000, the Congressman $7,500, but the pittance of the examiner has been increased in all these years only some ten per cent, while in relative value and purchasing power it has been more than cut in two.

This is the amount paid to the primary examiners. It has to be worked up to, and is the highest attainable unless one gets to be Commissioner or one of the half dozen higher officers. The lower lights among the examiners get less, and yet to be eligible they must be graduates of technical schools or have an equivalent education. Their duties lead to a knowledge of patent law and a comprehensive acquaintance with the details of the arts or classes of inventions upon which they specialize, which makes them valuable to industry, and twenty-five per cent of them resign every year to accept more remunerative positions outside. The present force is inadequate, and the salary offered does not attract and hold the kind of men that should be trusted with the important issues which a patent examiner decides, for in most cases he is the deciding authority. The result is delay and inefficiency, which cost the industries of the nation much more than the appropriation for adequate and efficient service would amount to.

In his perplexity the Commissioner of Patents has appealed to the engineer, and the National Research Council, Engineering Council and numerous other engineering, scientific and industrial organizations have urged their members, as we urge our readers, to write their Congressmen and Senators, especially Senator George W. Norris, chairman of the Joint Patent Committee, soliciting their favorable consideration of the increase in salaries and staff proposed in the Nolan Patent Office Bill H. R. No. 11,984 without reduction or riders. The present income derived by the Patent office from applications for patents meets all the expenses of the office, and the increase in salaries will not come from the taxpayers, but is provided for by an increase in the fees for patents. This gives an added reason why the Government should be anxious to give inventors the best service possible.

What Is Wrought Pipe?

ONE would naturally suppose that when he specified "wrought-iron pipe" he would get, or at least be entitled to, pipe made of wrought iron. Steel pipe is commonly known and billed, however, as "wrought pipe," and jobbers and contractors are prone to install steel pipe instead of the more expensive wrought-iron material when the latter is specified, and are able to get away with it in court on the plea that "wrought-iron pipe" is a trade term meaning either wrought-iron or steel pipe as distinguished from cast-iron pipe.

In order that there may be on record an authoritative utterance upon this subject, the Executive Committee and Advisory Board of the National Pipe and Supplies Association has forcibly called attention to the distinction made by the American Society for Testing Materials in the following resolution:

Whereas, The distributors of pipe for many years used terms to designate the various types and makes of pipe that have not been duly descriptive of same; and

Whereas, It is the desire of this association to co-operate in every way with the manufacturers in the development of trade practices and customs of accepted merit, and which will be fair and intelligible to the manufacturer, distributor and public alike;

It Is Hereby Resolved, By the officers and members of the Executive Committee and Advisory Board of the National Pipe and Supplies Association in their fall meeting, held in New York City on Thursday, Nov. 11, that it is their judgment that the terms employed by the American Society for Testing Materials in differentiating between Iron and Steel Pipe—namely: (a) Welded Wrought-Iron Pipe; (b) Welded Steel Pipe—should be accepted and adhered to by the distributors of both iron and steel pipe, this being in the interest of the manufacturers of the pipe, those who distribute it and those who use it, each being entitled to know clearly and without doubt the make and quality of the pipe involved in the transaction.

This means, if it means anything, that welded pipe is pipe that is welded no matter what it is made of; that welded steel pipe is pipe that is made by welding steel; that welded wrought-iron pipe is pipe that is made of wrought iron by the welding process and that "wrought-iron pipe" is pipe that is made of wrought iron whatever the process of manufacture.

Safety-Valve Outlets

A FURTHER thought—brought out of one of our readers, too modest to advance it himself, by our recent editorial on "Safety Valve Outlets."

He says that in the good old days in New England, previous to the war, all real boiler makers placed on each end of the boiler a good-sized steam outlet, fitted with a forged steel nozzle. Each nozzle was large enough to discharge all the steam the boiler could make. One of them was connected to the steam main, and the safety valve was mounted upon the other. When two valves were required, a Y-base connection was used. The steam could be taken off front or back according to conditions or the user's fancy.

If such construction were required it would obviate difficulties like those which arose in Ohio and which called out the editorial in question. In that case a boiler maker fitted a seventy-two-inch boiler with a reinforcement pad for a two and one-half-inch safety valve and a tapped hole for another one and one-half inches in diameter and got away with it because there are specially high-lift safety valves made in those diameters that will discharge five pounds of steam per hour for each square foot of heating surface that the boiler contained. The Ohio Board of Boiler Rules has since adopted the following:

Safety valves of high relieving capacities which meet the requirements of the 1918 edition of the American Society of Mechanical Engineers' Boiler Code may be used on fire-tube boilers, provided the bases of such valves, either screwed or flanged, are cast as an integral part of the valve body and the bases are made to correspond to the sizes required for the intermediate lifts and corresponding relieving capacities given in Table 15, appendix, 1918 edition of the A. S. M. E. Boiler Code.

The A. S. M. E. Code will have to be revised to preclude a boiler maker from providing a safety valve opening large enough only for a maximum-lift valve. Such an opening is a standing invitation for the mounting of an inadequate safety valve, for the ordinary man would put on an ordinary valve of the size that the opening called for. Only the specialist or the inspector would know that a high-lift valve was the only one that would do, and that the owner was committed to the use of that type when he bought the boiler.

Neither the A. S. M. E. committee nor the Ohio Board of Boiler Rules would be warranted in prescribing that all boilers should be provided with the two similar nozzles fore and aft suggested by our commentator, but purchasers can specify them and it is a good thing to do. If the boiler maker objects because more than one safety valve is required, tell him that you will use a yoke or Y connection.

High Capacities in the Average Plant

IN THE power plant high capacity has been considered desirable, as supposedly it goes hand in hand with economy and brings a greater return on the investment. In the ordinary plant capacities of from twenty-five to forty per cent over rating have shown encouraging results. Central stations are in the habit of running up to two hundred per cent of rating and above, and this has led engineers in industrial establishments to follow the same practice, which in numerous cases has resulted to their disadvantage.

High capacity necessarily means high-class operation, and this is not always possible in the average plant. When operating at much over rating, it is necessary to be assured of the cleanest of feed water, such as is obtained in surface condensing installations, the use of raw water under these conditions often being disastrous from the standpoint of boiler maintenance. Draft and other conditions affecting the furnace must necessarily be the most favorable. As a matter of fact, the ordinary industrial plant is not yet ready for the capacities obtained in central-station practice. It is better to operate such a plant at a conservative rating, decreasing the amount of attendance required, repairs and depreciation. High-speed duty is something that must be accompanied by high-speed operating conditions, and these are not generally found in manufacturing plants.

In such plants better over-all results will obtain if the following four points are kept in mind: First, keep the wheels turning under all conditions; second, keep the economy at a reasonable figure; third, keep the maintenance low; fourth, keep the men contented to stay on the job.

It is queer how the admitted ex-profiteering on the part of a very few quite exceptionally naughty coal men makes the price of coal so universally high.

CORRESPONDENCE

Why Does a Leaky Compressor Valve Get Hot?

Replying to Donald McFee's question in the Nov. 16 issue, page 795, "Why Does a Leaky Compressor Get Hot?" heating of the valve is caused by the friction produced by air blowing or wiredrawing past the valve. Dr. Steinmetz states that the same thing happens when high-pressure steam is throttled by using an ordinary hand valve. This will also occur in the water end of a pump working on high pressure.

At one plant we operated a vertical triplex pump that was fitted with brass check valve and bushings. When the check valve began to leak, the pump barrel would become quite hot. G. M. MATTHEWS.

Dover, N. J.

Is Hydrogen Gas Sometimes the Primary Cause of Boiler Explosions?

In discussing a recent water-tube boiler explosion with a well-known boiler inspector, the conversation developed the information that, to all appearances, the boiler was in perfect condition and was working at probably less than 50 per cent of rating, also that the recording gage showed but 140 lb. pressure at the time of the explosion, while the working pressure allowed by insurance and state inspectors was 175 lb. The water was at about two gages, and all gages and water column were in good order.

One of the drums ruptured through the longitudinal seam between the rivet holes, tearing the sheet for about six feet. Several rivets were sheared in the flange of the front head. Chemical and physical analysis of the steel in the ruptured sheet showed it to be standard. The boiler had been in service about eight years. After an investigation, the insurance and state boiler board found no reasonable cause for the accident.

During thirty-six years' experience I have read of many so-called mysterious boiler failures. About twenty-four years ago I had charge of three water-tube boilers, equipped with shaking and dumping grates and a damper regulator. As we were burning a mixture of buckwheat and run-of-mine coal, the main damper could be almost closed without smoke leaking through the setting. In cleaning fires, it was customary to wing over and dump the ash and clinker into the ashpits and clean them immediately after cleaning fires.

On one occasion, just after cleaning fires, I was wetting down the ashpit, which contained a considerable quantity of red-hot clinkers, and just as the water struck a large red-hot clinker near the back of the pit, a violent explosion occurred in the furnace, blowing both firedoors open, throwing fire out onto the floor and blowing me about twenty feet back against a large brick pillar, behind which I scrambled as quickly as possible, thinking that a tube had burst. I was somewhat burned, but not seriously. Beyond the fire and ashes that had been blown out on the floor in front of the boiler, everything was normal.

After studying the matter, we concluded that the explosion was caused by hydrogen gas, as follows: There was probably a small hole in the fire near the back end, and directly under this hole was a red-hot clinker. When the water struck this clinker, the resulting steam was drawn through the hole into the furnace and, combining with the gas from the fresh charge of coal, formed an explosive mixture. If the damper had not been nearly closed, the draft would have taken enough excess air through the hole in the fire to have made the gas and air mixture non-explosive.

I can readily imagine a similar set of conditions where the explosion might be violent enough to cause an initial rupture of some part of the boiler which, through the sudden release of water under steaming temperature and pressure, might result in a serious explosion. For instance, a tube might develop a slight leak that would spray just enough water into the furnace to be instantly superheated and, if combined with the proper volume of gas, to make an explosive mixture which would instantly be ignited with results that no one could foretell.

The fact that no defects could be found in any part of the metal or accessories of the boiler under discussion leads me to believe that possibly a hydrogen-gas explosion caused the initial rupture. I have read a number of accounts of boiler explosions in which statements were made that two reports were heard in quick succession, which would seem to indicate that some such action had taken place.

I am offering this as a possible solution of such cases where there seems to be no good reason for an apparently strong, well-designed boiler to explode.

Cleveland, Ohio. C. A. GREEN.

[Water or steam could be projected onto a furnace fire, resulting in the formation of enough water gas to dislodge a boiler from its setting and thereby produce a rupture with the same result as the explosive effect of a rupture from internal pressure. The "explosion" while wetting down clinkers and blowing the fire out of the firedoor may have been due to the formation of water gas or only to the formation of steam. The writer's notion that hydrogen was formed is probably wrong. Hydrogen cannot be disengaged from water or steam at ordinary furnace temperatures.—Editor.]

Socketing Hoisting Ropes

In reply to the article, "Socketing Hoisting Ropes," on page 474 of *Power*, Sept. 21, 1920; over fifteen years ago we used open-end wire rope sockets, which were discarded in favor of what we consider a better method of attaching ropes to cages and skips. I am inclosing a photograph showing the method we have adopted instead. This is 1¼-in. rope attached to a large double-deck cage, the average load amounting to about 17,000 lb. We double our 1¼-in. wire ropes back five feet around a thimble and force eight 1-in. cold shuts around this piece with a heavy sledge. One-inch ropes are bent back 4 ft. and five ⅞-in. cold shuts are used. This outlasts the rope itself, whereas the open-end socket requires continual watching and renewing, and water worked in around the rope and rusting took place. When the cage or skip reached the bottom, should there be any slack in the cable, there was a sharp bend at the top of the socket, and as a consequence the wires were broken in the babbitt. Sometimes a number of wires were broken without being noticed and the rope reached a dangerous condition before being resocketed.

METHOD OF ATTACHING CABLES TO CAGE

Norway, Mich. THOMAS PASCOE.

Why Exempt Oil-Country Boilers?

In the issue of Nov. 2 I read an editorial on "Why Exempt Oil-Country Boilers?" The boilers used in the oil fields should be subject to inspection, and the valves, fittings, construction and installation should be made to conform to the A. S. M. E. Code the same as any boilers that are used for factory or other purposes.

Many of these oil-field boilers are operated by men who do not have the slightest idea of the destructive power stored in them. Such boilers are just as dangerous as any others, and while we are practicing and preaching "Safety First" to protect the employee and the employer, let us also take into consideration these boilers. Following are a few instances that have come to my notice:

I have found that staybolts had been removed and gas-pipe plugs screwed in their place. Safety valves of the lever type have been so loaded with weights that I doubt if they would blow off at 250 lb. instead of 100 as the safe pressure. I have found pipe plugs screwed into the safety-valve outlet, also into the blow-off pipe, so that the boilers could not be blown off regularly. There were also boilers with no water glass and with gage cocks not in the best of working order. Holes had developed in the sheets below the grates, and wooden plugs have been found driven in them to make them tight.

In one instance the front flue sheet below the tubes was found to be almost as thin as tissue paper and the handhole plate did not have over an ½-in. bearing surface. Tubes were pulling out of the front tube sheet, and the fusible plug had melted owing to low water and a solid plug had been inserted in its stead.

Under such conditions is it any wonder that boilers explode? Why then should the oil-country boiler be exempt if human lives are to be protected?

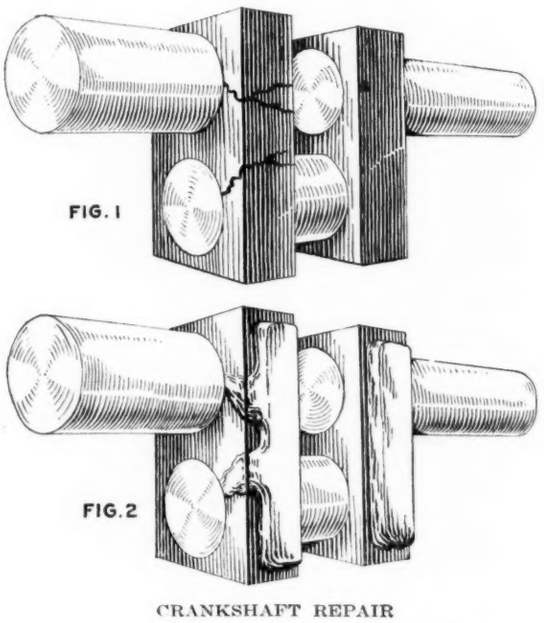
Olean, N. Y. CHARLES W. CARTER, JR.

Oil-Engine Crankshaft Repair

A repair job that may be of general interest was completed recently at the municipal power plant in Clayton, N. M. The crankshaft of a 180-hp. single-cylinder oil engine developed the two cracks indicated in Fig. 1.

The expense of a new shaft weighing over four tons, and slow delivery, influenced the decision to weld the old shaft. With an acetylene torch a cut was made where the cracks were visible until it was certain that the bottom of the cracks had been reached, the cut varying from 1½ to 4 in. deep. These cracks were then filled in with an electric arc weld, using steel electrodes of as near the same kind of metal as the shaft as could be obtained.

Then two pieces of round shafting 5⅞ in. in diameter were cut about 30 in. long and one placed on either side



CRANKSHAFT REPAIR

of the throw of the crank, as shown in Fig. 2, well overlapping the old cracks. These were built up with an electric arc weld until they appeared as integral parts of the shaft. After the job was completed, the engine was placed in operation about Aug. 1 and has been running from 18 to 24 hours a day for three months with no sign of any defects. The work was done without the labor of removing the shaft from the bearings, which is a great saving in this kind of repair work. J. H. BENDER.

Clayton, N. M.

Steel Foundations for 30,000-Kw. Horizontal Turbo-Generators

My attention has been called to an article by J. R. James in the Oct. 26 issue, page 646, in the synopsis of which the statement is made that the use of steel foundations for large units has been initiated at Detroit.

This is not the case. This company has been using steel foundations exclusively for turbines for the last ten years and has had in operation for two years a 30,000-kw. unit on a steel foundation in the Riverside Station of the Minneapolis General Electric Co. A second turbine of the same size is on order for this plant, which will also be put on a similar steel foundation.

Some three or four years ago the Twin City Rapid Transit Co. put a 20,000 or 25,000-kw. unit on a steel foundation after seeing a 15,000-kw. turbine operating in the Riverside Station on a steel foundation.

Chicago, Ill. H. BOYD BOYDON,
Mechanical Engineer,
Byllesby Engineering & Management Corporation.

[The word "initiated" was inadvertently used by the editor, who wrote the synopsis of Mr. James' article. *Power* had previously published several articles in which steel foundations for turbo-generators were featured.—EDITOR.]

Removing Broken Wedge Bolts

On page 632 of the Oct. 19 issue Mr. Baker illustrates his method of removing broken wedge bolts. I believe that his way is the approved method of making

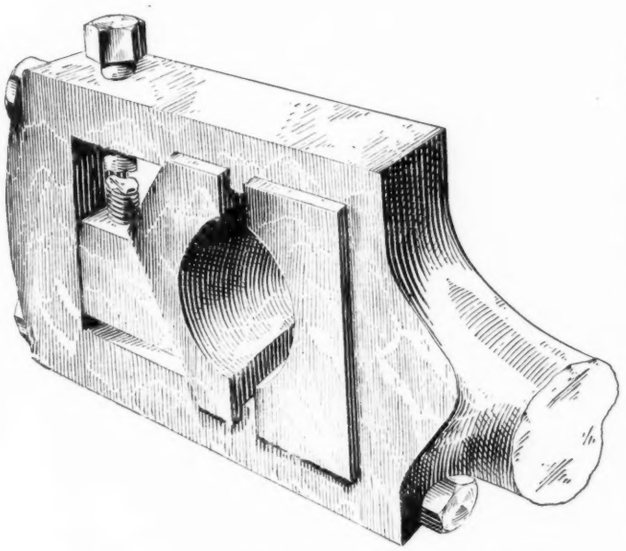


FIG. 1. HATCHET-HEAD WEDGE AND BOLT

wedge bolts. The slotted ends certainly save time in removing them when broken. With the hatchet-head connection, where but one bolt and hole are used (Fig. 1), I have a special chisel and cut a slot in the broken bolt, then unscrew as Mr. Baker suggests.

Where bucket air pumps are used, it is a source of annoyance to be forced to drill out the broken studs used in coupling the bucket rod to the bucket, as shown in Fig. 2. With a small space to work in and time a big factor, it saves patience and perhaps much cussing to drill a ¼-in. hole in the stud (as a help in locating center at a later time) when the stud is being entered the first time.

This ¼-in. hole will act as a lead, and as the studs

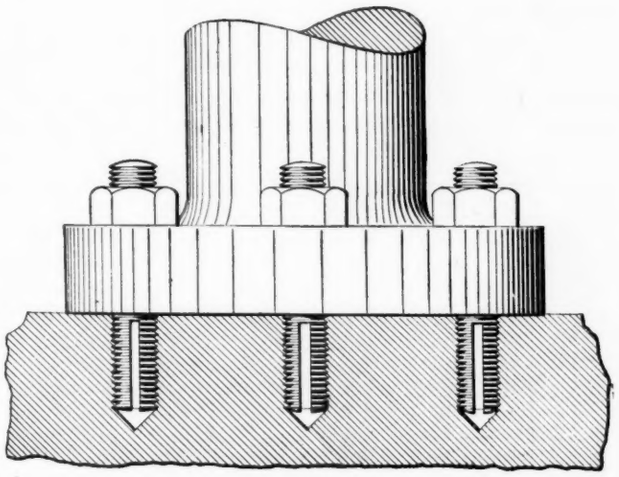


FIG. 2. HOLES DRILLED IN THE STUDS HELP IN REMOVING THEM

invariably break off flush with the bucket and cannot always be backed out, the job of drilling is simplified and the time required is actually cut in two.

New York City. C. W. PETERS.

Preventing Steam in Compressor Water Jacket

John T. Sharp, on page 796 of the Nov. 16 issue, calls attention to a trouble he had with an air compressor. Although he corrected it in a common-sense way, it might be proper to offer a supplementary explanatory remark.

It will be remembered that at the highest point of the water jacket of his compressor there was a ¼-in. pet cock that was intended to be opened occasionally to release steam, and as the opening was neglected, the pet cock was removed and an open connection made to the main overflow.

It does not seem to be best to let the story end there, because as it stands it suggests that the water in the water jacket gets hot, whereas it never gets hot at all. On any modern compressor with normal jacket-water circulation the water at the overflow should not be even blood-warm.

On the compressor under discussion the water was piped into the head-jacket at one end of the cylinder near the bottom, circulated through the cylinder jacket, and was then discharged from the other head-jacket near the top, flowing into the overflow funnel from the open end of the pipe.

It happened that there was, at the top of the cylinder, a small portion of the water jacket above the overflow outlet, and here the water would remain more or less stagnant and would at times get quite hot, occasionally reaching the boiler point, and as a means of relief the pet cock was used. The compressors of this type are now sent out by the makers with a little overflow pipe similar to that provided by Mr. Sharp.

New York City. FRANK RICHARDS.

Air for Combustion

C. C. Phelps' article, page 704 of the Nov. 2 issue, leads me to suggest that the usual assumption of 11.5 lb. of air per pound of combustible is true only if carbon is the sole combustible. The theoretical air requirement for any solid fuel from anthracite to lignite is

$$34.56\left[\frac{C}{3}+\left(H-\frac{O}{8}\right)+\frac{S}{8}\right]$$

when C, H, O and 3 are given in decimal parts for one pound of fuel. Mr. Phelps' method would be right if

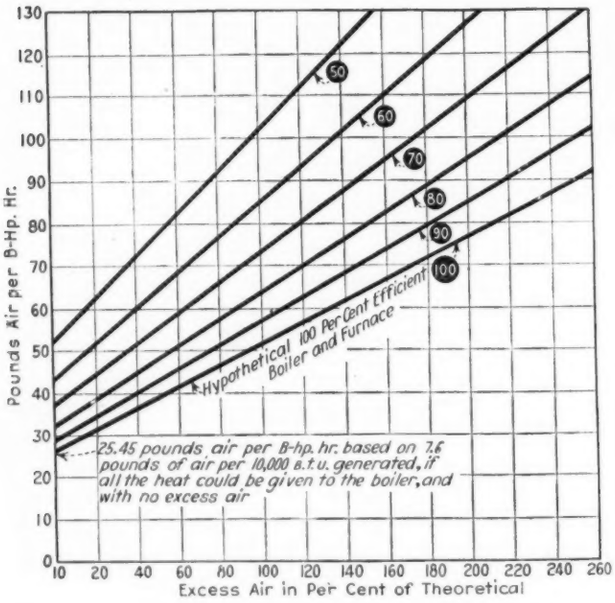

Pounds Air per B-Hp. Hr.
Excess Air in Per Cent of Theoretical
50
60
70
80
90
100
Hypothetical 100 Per Cent Efficient Boiler and Furnace
25.45 pounds air per B-hp. hr. based on 7.6 pounds of air per 10,000 B.t.u. generated, if all the heat could be given to the boiler, and with no excess air

FIG. 1. CHART FOR POUNDS OF AIR REQUIRED PER BOILER HORSEPOWER, BOILER AND FURNACE EFFICIENCY AND PER CENT EXCESS AIR BEING GIVEN

no hydrogen, oxygen or sulphur were present. These elements have a very decided effect on the result.

I have had to calculate the air requirements for a wide range of solid fuels—Arkansas anthracite, Pennsylvania bituminous, Indiana and Illinois coals, Western lignites and hogged wood. For this reason, about a year ago, I determined the quantity of air theoretically

AIR REQUIRED FOR DIFFERENT FUELS

	Air Theoretically Required per Lb. of Coal	per 10,000 B.t.u Generated
Illinois bituminous, poor quality	7.0	7.6
Illinois bituminous, good quality	9.4	7.55
Anthracite, average	10.2	7.65
Semi-bituminous, Pocahontas	11.2	7.5
Liquid fuel	14.24	7.04

required for thirty-five different coals, etc. This was done because comparatively little information was available in handy form and it was necessary at times to have the information in such shape that it could be quickly used. This was not original work, but simply the gathering together of scattered information and the calculation for data to connect one thing with another.

The kind or grade of the fuel has much more effect on the quantity of air (theoretical) required than on the quantity required per boiler horsepower per hour. The figures in the table are taken from a small book, "Finding and Stopping Waste in Modern Boiler Rooms," published by the Harrison Safety Boiler Works.

On the same page is a curve plotted with available hydrogen per pound of combustible as abscissas and pounds of air per 10,000 B.t.u. generated. I found in my checking, by calculating for thirty-five widely varying fuels, that the deviation from an average of 7.6 lb. of air per 10,000 B.t.u. generated was less than 2½ per cent in all cases but one.

As the air requirement per 10,000 B.t.u. was not as convenient as the air per boiler horsepower per hour, the corresponding value, theoretical, of 25.45 was determined. This figure is for a 100 per cent efficient boiler and furnace, getting perfect combustion with the theoretical air supply. The accompanying chart, Fig. 1, was then made, by means of which, assuming a given excess air supply and a probable efficiency, the air necessary could be read at a glance.

For example, assuming 100 per cent excess air and 60 per cent efficiency, it is seen nearly 85 lb. of air per

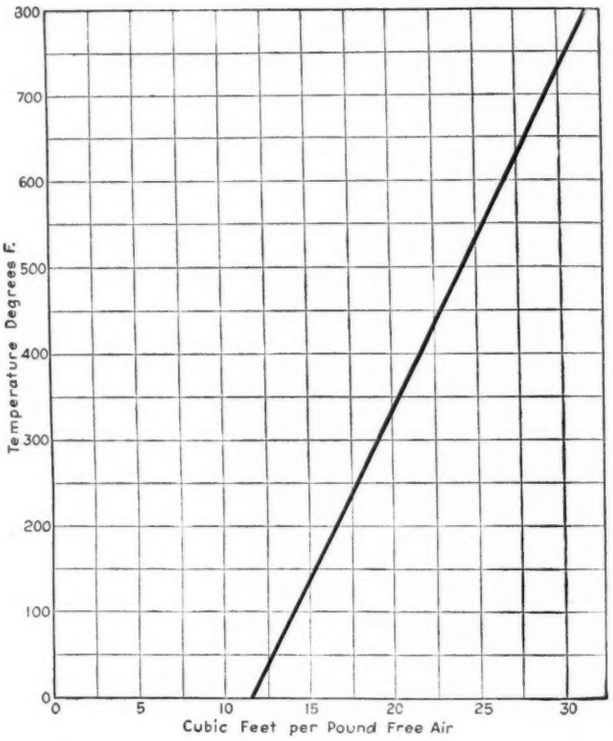


FIG. 2. CHART SHOWING CUBIC FEET OF AIR PER POUND AT VARIOUS TEMPERATURES

boiler horsepower per hour will need to be furnished. If this is for a 300-hp. boiler, the values are 25,500 lb. per hour, or 425 lb. per minute.

The other chart, Fig. 2, is for quick conversion, at standard barometer, of pounds to cubic feet. The conversion for the example given at, say, 75 deg. F. in one pound equals 13.5 cu.ft. Then the amount of air per boiler horsepower per hour times 13.5 equals 344,250 cu.ft. per hour, or 5,737.5 cu.ft. per minute, but considering the rough assumptions, 350,000 and 5,800 cu.ft. would be used.

The difference between the volume of air supplied at stack temperature and the volume of the actual flue gases passing up the stack is so small that the second chart can be used to arrive at flue-gas volume.

Chicago, Ill. O. R. McBRIDE.

INQUIRIES OF GENERAL INTEREST

Very High Vacuum Uneconomical for Condensing Engine—Why is it not economical to maintain higher than 26 to 27 in. vacuum for a reciprocating condensing engine? J. N.

A higher vacuum entails greater loss from cylinder cooling, and usually, the additional engine power obtained does not compensate the cost of overcoming greater air leakage in connections between the engine and condenser and the cost of handling the necessary additional cooling water.

Determining Constancy of Lead—How can it be known whether a governor of an engine varies the lead? C. D. F.

The constancy of lead would be shown by comparison of indicator diagrams taken with different loads on the engine. Or, block the governor to different positions and ascertain for each position of the governor whether steam is admitted at the same point of travel of the crosshead, just before completion of an exhaust stroke.

Cast-Iron Chimney Caps—Why are brick chimneys provided with cast-iron caps? C. T.

Cast-iron chimney caps are used as copings to bind the top courses of the brickwork together and protect it from the weather. For many situations a more economical and more durable construction can be obtained by embedding an iron ring in the masonry near the top for holding the brickwork together and capping the chimney with terra cotta or other refractory material, made up in interlocking sections, with suitable tile joints and overhang for drainage and drip of rain water.

Choice of Two Speeds for Given Engine and Load—Does a 12 x 12-in. engine require more steam to develop 50 hp. when running 300 than when running 250 r.p.m.? W. H. P.

Under ordinary conditions the most economical point of cutoff for non-condensing engines is between one-fourth and one-third of the stroke. The most economical speed for a given load mainly depends on the point of cutoff required with the given initial pressure to obtain the necessary mean effective pressure, which for development of 50 hp. and 300 r.p.m. of a 12 x 12-in. engine would be 24.3 lb. m.e.p. and for 250 r.p.m. would be 29.1 lb. m.e.p. Hence whether 300 or 250 r.p.m. would be more economical for development of 50 hp. would depend on the initial pressure. The lower speed would be more economical for initial pressures in excess of about 50 lb. gage.

Use of Receiver on Compound Engines—Why is not a receiver employed for tandem-compound engines as well as for cross-compound engines? R. N. G.

On a tandem-compound engine, as the high- and low-pressure pistons are on the same piston rod, an exhaust stroke in the high-pressure cylinder is simultaneous with a power stroke in the low-pressure cylinder and the clearance space of the passages from one cylinder to the other usually affords sufficient temporary storage space to act as a receiver for steam that may not be admitted after cutoff in the low-pressure cylinder. In a cross-compound engine, for greater uniformity of rotation, the separate cranks of the high-pressure and the low-pressure cylinders usually are set 90 deg. apart, and exhaust of the high-pressure cylinder is released approximately during one-half of a power stroke and one-half of an exhaust stroke of the piston in the low-pressure cylinder, making it necessary to provide a receiver for storage of the high-pressure exhaust to prevent undue back pressure on the high-pressure piston and afford better distribution of steam to the low-pressure cylinder.

Lap of Steam Valves of Double Eccentric Corliss—How much lap have the steam valves on a double eccentric, long-range cutoff Corliss engine when the wristplate is in its central position? L. T.

For cutoff to occur later than one-half stroke, in place of the steam valves lapping over the edges of the ports they need to have negative lap; that is, when the wristplate is central, the valves would be partly open, the amount depending on the maximum length of cutoff and desired lead. The cutoff gear must act before the wristplate has been swung over to the farthest point of its travel to one side or the other of its central position, and as such displacement occurs for 90 deg. rotation of the eccentric, or approximately for one-half stroke of the piston, it follows that for a longer period of admission the valves must be set so they begin to open before the wristplate comes up to its central position, and this results in considerable opening, or negative lap, when the wristplate reaches the central position. To correct the lead, the eccentric must be set back of its 90-deg. position with respect to the crank.

Reversing Polarity—Two direct-current compound interpole 400-kw. generators, carrying a motor load, reversed their shunt-field polarity three times within four months. The generators and motors were free from grounds when these reversals took place. In nearly every instance the trouble occurred during a period of unusually low voltage, caused by low steam pressure. At times only one generator was reversed; again both were affected. What is the solution of the trouble? D. F. Z.

Reversal of polarity may be due to either of two causes. If a generator, driving a motor load that has considerable inertia, slows down, the motors will not decrease in speed at the same instant that the generator does, but for a short period may maintain a speed where their counter-electromotive force will be higher than the voltage of the generator, and will supply a current back to the generator in a reverse direction to the original load current. This current will flow through the series-field winding in a reverse direction and reverse the polarity of the generator, and probably this was the cause of the trouble. There is also the possibility that one machine operated at a lower speed, on low steam pressure, than the other, and as a result one machine developed considerably higher voltage than the other. The machine of the higher voltage would motorize the unit operating at the lower emf., and this would result in reverse polarity of the motorized machine.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Interpretations of the A.S.M.E. Boiler Code

THE FOLLOWING answers to requests for interpretations of the Boiler Code have been prepared by the Boiler Code Committee and approved by the Council of the American Society of Mechanical Engineers. The formal inquiry and reply are given together with explanatory references to the code and illustrations where necessary for a better understanding of the interpretations as issued.

Case No. 259 (Reopened)—Inquiry: Is it allowable under the requirements of the A. S. M. E. Boiler Code to fit a high-pressure steam boiler with a blowoff connection larger than 2½ in. in case it is to be used initially for low-pressure steam or hot-water heating, or will it be necessary under the requirements of Par. 308 to apply two or more 2½-in. blowoff connections for the return connections to the boiler?

Par. 308 provides that the minimum size of pipe and fittings for the bottom blowoff shall be 1 in. and the maximum size shall be 2½ in. Par. 308 is in Part I, Section I of the Code, which refers to "New Installations of Power Boilers." The limitation of the maximum size of blowoff connection to 2½ in. is to prevent excessive reactive stresses in the piping due to opening a large line at high pressures. Section II of Part I of the Code, referring to "Heating Boilers," makes no mention of a maximum size for blowoff connections.

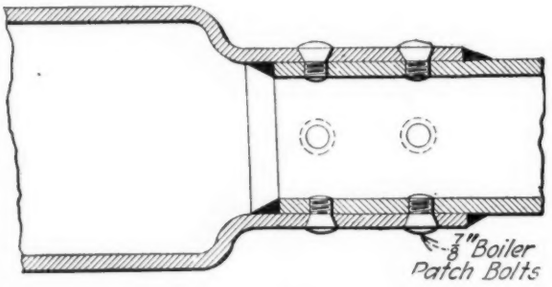
Reply: It is the opinion of the committee that a boiler could be initially fitted with a blowoff connection larger than 2½ in. size when intended for use as a steam or hot-water heating boiler, and when converted to a steam boiler, if to operate at over 15 lb. pressure, but not exceeding 100 lb. pressure, a reducing fitting could be used at the opening to reduce to the pipe size required for the blowoff connections by Par. 308.

Case No. 285 (Reopened)—Inquiry: Is it permissible under the rules of the Boiler Code to use standard extra-heavy cast-iron flanges and fittings on pipe connections between boilers and attached-type superheaters, and on the ends of superheater-inlet headers for pressures up to 250 lb. per sq.in. It is pointed out that neither the inlet-pipe connections nor the superheater-inlet flanges would be subjected to other than saturated steam temperatures.

Reply: It is the opinion of the committee that the flanges and fittings referred to may be made of cast iron, provided the temperature of the steam does not exceed 450 deg. F. as specified in Par. 12.

Par. 12 provides that cast iron shall not be used for nozzles or flanges attached directly to the boiler for any pressure or temperature, nor for boiler and superheater mountings such as connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. F.

The destructive effect of high temperature steam on cast iron is assumed to be negligible below 450 deg. F. The temperature of saturated steam at 250 lb. per sq.in. gage is about 406 deg. F.



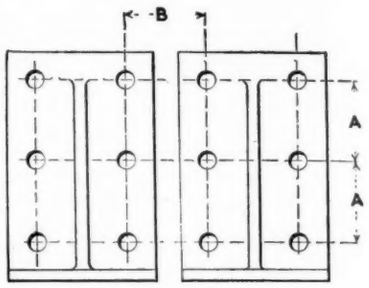
CASE 305. A PROPOSED METHOD OF CONNECTING WROUGHT-STEEL HEADERS

Case No. 305—Inquiry: Is it permissible, under the requirements of the Boiler Code, to connect sections of wrought-steel headers, one of which is shrunk or forced over the end of the other, making a close fit and secured by means of bolts of ample cross-sectional area, the joint being calked or autogenously welded to insure tightness, the design of the joint to be such that it will be of ample strength, neglecting the holding power due to shrinking or forcing one section over the other and the holding power of the autogenous welding?

It is provided in Par. 186 of the Code that autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code, and where the safety of the structure is not dependent upon the strength of the weld. The accompanying illustration shows one type of construction to which this case might apply.

Reply: It is the opinion of the committee that while the construction described is not a desirable one, it is not prohibited by the Code.

Case No. 307 (Reopened)—Inquiry: Is it permissible to so locate the supporting lugs on horizontal return-tubular boilers where more than four lugs are required and under Par. 323 of the Code, must be set in pairs, that those in each pair come close together, or must the horizontal distance between the center lines of rivets attaching the adjacent lugs to the shell be at least equal to the vertical spacing of rivets that is required for lug attachments in Par. 323, as shown in the accompanying illustration?



CASE 307. METHOD OF LOCATING BOILER SUPPORTING LUGS ON BRACKETS

Par. 323 provides for the support of horizontal return-tubular boilers by steel lugs and that not more than two of the rivets attaching the lugs to the shell shall come on the same longitudinal line on each lug. This latter requirement is to avoid excessive weakening of the shell by rivet holes. This paragraph further provides that if more than four lugs are used, they must be set in four pairs. The question then arises as to the effect on the strength of the shell due to the four rivet holes for the two lugs of a pair, if these lugs are set close together.

Reply: There is no requirement in the Code specifying the distance apart of the lugs forming pairs as required by the last sentence of Par. 323. It is the intent of the Boiler Code that the distance between the lugs should be such as to give at least ½ in. between the edges of the lugs and not more than 2 in. The load should be equalized between the two lugs.

A maximum distance between the lugs of a pair is necessary to provide against unequal distribution of the load between the lugs.

Case No. 310—Inquiry: (a) Can a type of boiler other than the horizontal return-tubular type have lap joints where the courses are over 12 ft. long?

(b) With butt and double-strap construction on longitudinal joints for boilers other than of the horizontal return-tubular type, is it required that the tension-test specimens be cut from the shell plate as provided in Par. 190?

Par. 190 provides that in horizontal return-tubular boilers with lap joints no course shall be over 12 ft. long. It further provides that with butt and double-strap construction longitudinal joints of any length may be used, provided the tension-test specimens are so cut from the shell plate that their lengthwise direction is parallel to the circumferential seams of the boiler, and the tests meet the standards prescribed in the specifications for boiler-plate steel.

Reply: (a) The restriction in length of lap joints to 12 ft. in Par. 190 of the Boiler Code applies specifically to boilers of the horizontal return-tubular type, but there is nothing in the rule which prohibits the construction of shells and drums of lengths exceeding 12 ft. for other types of boilers.

(b) Inasmuch as the first sentence of Par. 190 applies specifically to horizontal return-tubular boilers, as pointed out in reply (a), it is the opinion of the committee that this prohibition does not cover other types of boilers.

Case No. 314—Inquiry: Is it the opinion of the Boiler Code Committee that a lap joint reinforced with a cover plate should be considered as an ordinary lap joint and the requirements for factors of safety given in Pars. 379 and 380 applied accordingly?

Pars. 379 and 380 are in Part II of the Code which applies to "Existing Installations." It is provided that the factor of safety shall be at least 4 for boilers in service one year after, and at least 4.5 five years after, these rules become effective. The factor of safety referred to is that in the formula:

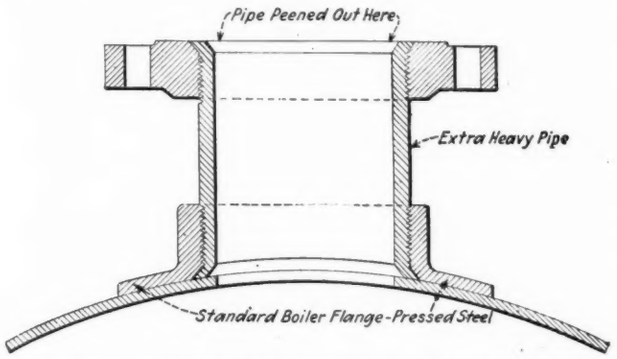
$$\textit{Maximum allowable working pressure} = \frac{TS \times t \times E}{R \times FS}$$

where

TS = Ultimate tensile strength of shell plates, lb. per sq.in.;
t = Thickness of shell plate, in weakest course, in.;
E = Efficiency of the longitudinal joint as determined by Par. 181 of these rules;
R = Inside radius of weakest course, in.;
FS = Factor of safety.

Par. 380 provides that the age limit of a horizontal return-tubular boiler, having a longitudinal lap joint, shall be 20 years, except that no lap-joint boiler shall be discontinued from service solely on account of age until five years after these rules become effective.

Reply: It is the opinion of the committee that a lap joint, even though reinforced by a cover plate, should be treated exactly the same as the simple form of lap joint, so that the factors of safety proposed in Pars. 379 and 380 for lap joints would be applicable.



CASE 317. PROPOSED METHOD OF MAKING PIPE CONNECTIONS TO BOILERS

Case No. 315—Inquiry: Is it to be understood that the requirements of Par. 323 of the Boiler Code, relative to the location of lugs and the distribution of rivets attaching them to the shell, applies to the small sizes of boilers referred to in Par. 324?

Par. 324 provides that horizontal return-tubular boilers between 54 in. and 78 in. in diameter shall be supported by the outside suspension type of setting, or at four points by not less than eight steel or cast-iron brackets set in pairs. A horizontal return-tubular boiler up to and including 54 in. in diameter shall be supported by the outside suspension type of setting, or by not less than two cast-iron or steel brackets on each side.

Reply: The requirements of Par. 323 of the Code are clearly limited to horizontal return-tubular boilers over 78 in. in diameter. It will be found that Par. 325 gives the requirements for attaching the lugs.

Par. 325 provides that the lugs or brackets shall be properly fitted to the surfaces to which they are attached. The shearing and crushing stresses on the rivets attaching the lugs shall not exceed 8 per cent of the following strength:

Crushing strength of steel plate, 95,000 lb. per sq.in. of cross-sectional area.

Shearing strength lb. per sq.in. of cross-sectional area of the rivet shank:

Iron rivets in single shear	38,000
Steel rivets in single shear	44,000

Values for double shear to be twice those for single shear.

Case No. 316—Inquiry: Is it permissible, under the requirements of the Boiler Code, for a boiler manufacturer to stamp a boiler as A. S. M. E. Code Standard, when it is fitted with a safety-valve nozzle or connection that is adequate only for safety valves operating at high lifts?

Reply: The way designated in the Code in which the size of the safety valve or valves that shall be used on any boiler is determined by their relieving capacity, and where the safety-valve opening corresponds to that required from such a valve or valves, the boiler is constructed in accordance with the A. S. M. E. Code in this respect and may be so stamped. The committee suggests, however, that where boilers are sold for a given operating pressure without knowledge of the type of safety valves that will be used, the safety-valve openings be proportioned for the intermediate lifts and corresponding relieving capacities given in Table 15 of the Code.

Table 15 of the Code gives the discharge capacities of spring-loaded safety valves with 45-deg. bevel seats for various sizes, ranging from 1 in. to 4½ in. in diameter at various pressures ranging from 15 to 300 lb. per sq.in. gage. In each case values are given for three lifts called "Minimum," "Intermediate" and "Maximum." The discharge capacities are given in terms of the heat value of the fuel burned per hour and also in terms of the pounds of steam generated per hour.

Case No. 317—Inquiry: If it is permissible, as indicated in Case No. 298, to fit a steam-outlet nozzle with a wrought-steel flange screwed to the outer end of the end neck to which the flange is threaded and peened over into a beveled part cut away from the flange, why should not this construction be acceptable for the attachment of the flange at the other end of the nozzle for attachment to the boiler shell?

The accompanying illustration shows the construction permitted under the interpretation of Case No. 298. This applied, however, only to the flange at the top of the nozzle. The present inquiry asks permission to use the same construction at the bottom of the nozzle as indicated in the illustration.

Reply: It is the opinion of the committee that this construction does not conform to the requirement of the last sentence in Par. 268.

The last sentence in Par. 268 provides that when the allowable working pressure exceeds 100 lb. per sq.in., a connection riveted to the boiler to receive a flanged fitting shall be used for all pipe openings over 3-in. pipe size.

Water-Power Permits Applied For

Application for license or preliminary permit for water-power projects were filed with the Federal Power Commission during the week ended Nov. 27 as follows (the name and address of the applicant, the site of the project, and the proposed use are shown): San Joaquin Light and Power Corporation, Fresno, Cal., San Joaquin River, public utility; Utica Mining Co., 1128 Merchants Exchange Bldg., San Francisco, Stanislaus River, mining; Nevada-California Power Co., First National Bank Bldg., San Francisco, Warren Slate and Leevining Creek, Mono County, Cal., public utility; City of Los Angeles, Department of Public Service, Kings River, Fresno County, Cal., public utility; Western States Gas and Electric Co., Stockton, Cal., Trinity and Humbolt Counties, public utility; Flathead Valley Electric Co., Old National Bank Bldg., Spokane, Flathead River, Flathead County, Mont., public utility; Catawba Valley Light and Power Co., Morganton, N. C., Wilson Creek, Caldwell County, N. C., public utility; San Joaquin Light and Power Corporation, Fresno, Cal., Kings River, Fresno County, Cal., public utility; Frank B. Pattee, Samuel Bernhard and J. T. Ross, Call Bldg., San Francisco, Stanislaus River, Calaveras County, Cal., use not stated; Home Colony (an association of citizens) Cody, Wyo., Kitty Creek, Park County, Wyo., community use; Southern California Edison Co., Edison Bldg., Los Angeles, San Joaquin River, Madera, and Fresno Counties, Cal., public utility.

Ten Ways to Kill an Association

1. Don't come to the meetings.
2. But if you do come, come late.
3. If the weather doesn't suit you, don't think of coming.
4. If you don't attend a meeting, find fault with the work of the officers and other members.
5. Never accept an office, as it is easier to criticize than to do things.
6. Nevertheless, get sore if you are not appointed on a committee, but if you are, do not attend the committee meetings.
7. If asked by the chairman to give your opinion regarding some important matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.
8. Do nothing more than is absolutely necessary, but when other members roll up their sleeves and willingly, unselfishly use their ability to help matters along, howl that the association is run by a clique.
9. Hold back your dues as long as possible, or don't pay at all.
10. Don't bother about getting new members. "Let George do it!"—*Michigan Architect and Engineer.*

Use and Inspection of Flexible Steel Cables

At the regular monthly meeting, Philadelphia Section, Association of Iron and Steel Electrical Engineers, "Instructions in the Care, Use and Inspection of Flexible Steel Cables" was the subject discussed by Dr. H. C. Boynton and W. Voigtlander. Dr. Boynton, using lantern slides, described the process involved in the manufacture of wire rope at the plant of John A. Roebling's Sons Co. The speaker characterized the present as being pre-eminently the age of metallic alloys. High-grade wire and wire rope are made from carbon steel having a tensile strength of from 220,000 to 300,000 lb. per sq.in. This high tensile strength is obtained by heat treatment, and 90 per cent of the steel used in wire rope is made by the open-hearth process.

W. Voigtlander discussed the subject of proper installation and maintenance of wire rope for hoisting purposes. He said that it had been conclusively demonstrated by repeated tests that the most efficient wire-rope attachment is made by a straight wire brush held in the conical basket of the socket by means of spelter (pure zinc). It was brought out in the discussion that no cable clip or clamp has ever been designed that will give the full strength to the cable. As to the lubrication of steel cables this varies from an application every day where conditions are severe, such as where acid fumes are present, to every two weeks or longer under ordinary conditions. The best method of lubricating a rope is first to heat it; but this can be done only by removing the rope from the sheaves. As a compromise the use of a fairly thick lubricant is recommended, applied hot if possible, using a shallow container and allowing the cable to run in the oil. In the installation of cable care must be exercised so as not to cause a kink in the rope, or this section will greatly reduce its life. The kinked portion will stand only approximately 75 per cent strain that the straight rope is capable of withstanding. Wire rope will safely stand a temperature of 400 deg. F. without affecting its tensile strength. At temperatures above 400 deg. F. its strength may be seriously reduced.

Abrasion is very seldom the chief cause for rejection of wire ropes. In almost all cases the wires of the individual strands break or the rope is damaged from outside causes, to the extent that it requires replacing.

Canada's Use of "White Coal"

Canada's per capita development of water power is now said to be higher than that of any other country except Norway. The figures are 0.54 hp. per capita for Norway and 0.26 hp. for Canada; the United States is far behind, with 0.07 hp. As for the total amount of developed and undeveloped water power, however, without regard to population, the United States comes first with 30,000,000 hp. and Canada second with 19,000,000 hp. These figures and the accompanying chart were prepared by the Canadian Commission of Conservation for the Bankers Trust Company of New York.

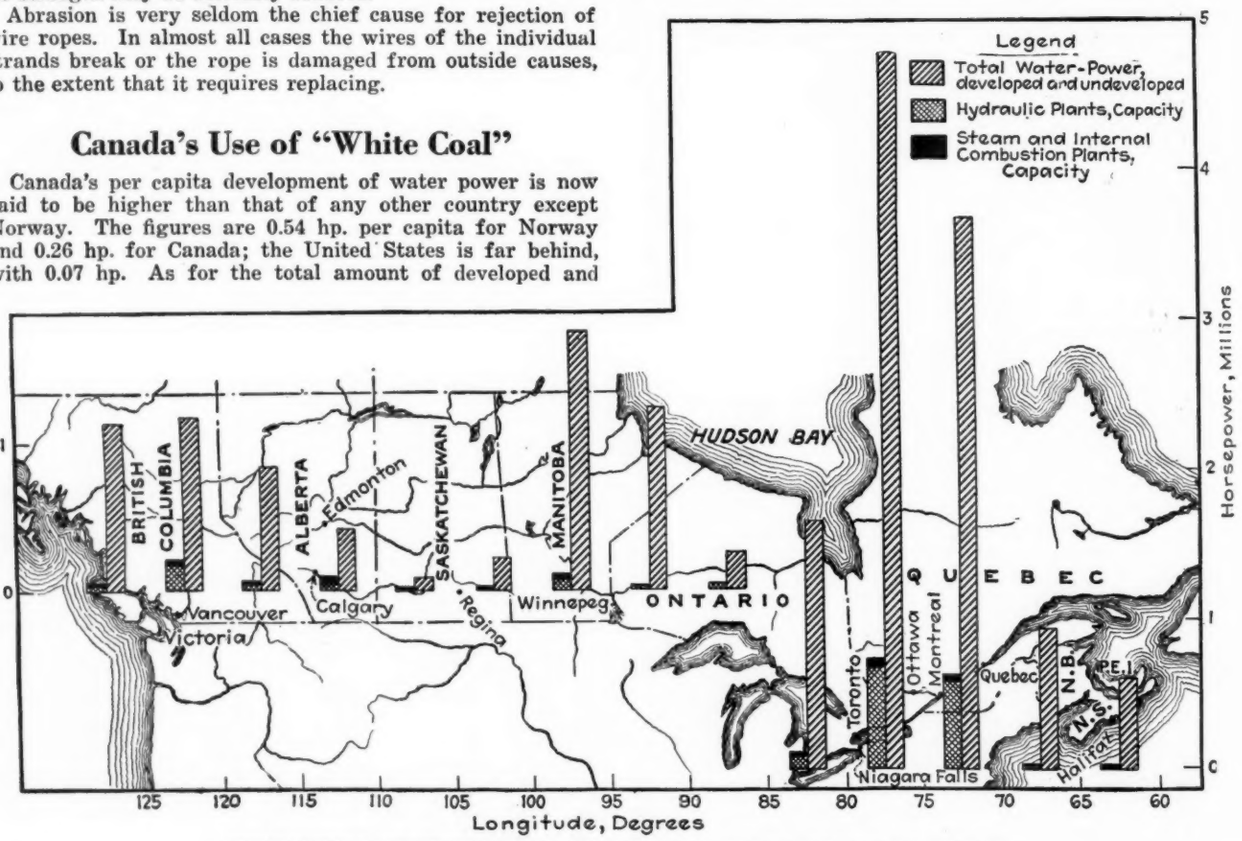
The chart reproduced here repesents graphically the figures given in the table. It shows the total capacity of central-station plants in various areas of Canada, each of which includes five degrees of longitude. For comparison the total of available and developed water power in each area is also shown. It should be noted that the figures of total water power are the estimated amounts of 24-hour low-water power, and that these amounts can be much increased, according to the amount of artificial storage available, the economic head that may be developed and the nature of the industry using the power.

HORSEPOWER OF THREE TYPES OF CENTRAL ELECTRIC STATIONS, AND THE TOTAL AVAILABLE WATER POWER, IN EACH DISTRICT

Meridian District	Horsepower of Central Electric Stations			Total of Used and Unused Water Power
	Hydraulic	Steam	Internal Combustion	
60– 65	1,406	23,502	777	620,800
65– 70	13,346	13,131	1,298	942,200
70– 75	596,463	36,325	253	3,690,000
75– 80	686,561	57,934	228	4,820,000
80– 85	112,183	8,135	2,117	1,660,000
85– 90	36,000	0	0	250,000
90– 95	11,800	250	6	1,227,000
95–100	78,550	23,169	0	1,743,500
100–105	0	9,979	3,101	228,500
105–110	0	17,278	1,531	83,000
110–115	31,980	50,835	1,332	406,000
115–120	48,634	5,603	1,525	841,000
120–125	182,620	32,010	755	1,185,000
125–Ala.*	37,075	10,051	0	1,135,000
Totals.....	1,836,618	288,202	12,923	18,832,000

* This district extends from long. 125° to the boundary between Canada and Alaska.

It is interesting to note that although Canada has been most industrious in utilizing her "white coal," the amount in use is only a small portion of the total which may be developed in the future; it is, nevertheless, proportionately far greater than our own development of water power.

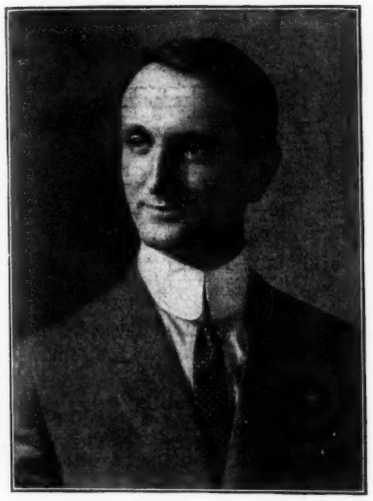


COMPARISON BETWEEN USED AND UNUSED WATER POWER IN CANADA

William T. Price

It is with deep regret that *Power* informs its readers of the death of William T. Price, chief engineer of the oil-engine department, Ingersoll-Rand Co., at his home in Easton, Pa., Nov. 7, 1920.

Mr. Price was born at Montreal, Canada, Sept. 28, 1883. After attending the Toronto Technical School for a few years, he entered the employ of the Constructor's Plant Manufacturing Co., of Buffalo, where he soon became chief engineer. He was then engaged by the Lackawanna Steel Co., where he realized that further technical education was necessary, so entered in 1903 Cornell University, where he completed the course in mechanical engineering, graduating in 1906.



WILLIAM T. PRICE

After a short service with the Wheeling Mould and Foundry Co. he was engaged by the De La Vergne Machine Co., first as sales engineer and subsequently as chief engineer and manager of the oil-engine department.

Leaving this company in 1917, he founded the Price Engine Corporation and brought out the design of a solid-injection oil engine bearing his name. The engine operates at a low compression without the aid of hot surfaces and attains the efficiency of the Diesel. Its manufacture was undertaken by the Rathburn-Jones Co. The Ingersoll-Rand Co. also engaged in the manufacture of the Price engine, and Mr. Price was, at the time of his death, chief engineer of the latter concern.

Mr. Price was a member of the American Society of Mechanical Engineers, and of the Engineers Club of New York City. He was an outstanding figure in engineering circles, being one of the very few American engineers that broke loose from European influences in engine design. Besides his mechanical ability, he possessed unusually keen business foresight. He was the exceptional inventor with sufficient business acumen to reap the benefits of his labor.

It was also Mr. Price's good fortune to be blessed to a high degree with the faculty of making friends. This was partly due to his youth and enthusiasm and partly to his consideration for the feelings of those with whom he came in contact. The humblest shop apprentice or cub salesman was accorded the same courteous treatment as the highest company official. It is little wonder that his acquaintanceship alone limited his circle of friends.

A preliminary statement of the general results of the census of Pennsylvania anthracite operations for 1919 has been issued by Director Sam L. Rogers of the Bureau of the Census, Department of Commerce. The summary shows a decrease in the number of breakers and also in the number of wage earners employed. The number of wage earners decreased from 169,174 in 1909, to 147,069 in 1919, or 13 per cent. Wages paid show an increase from $92,169,906 in 1909 to $210,202,511 in 1919. For operating cost a decided increase is shown. The quantity of coal produced shows an increase over that for 1909 of but 6,302,000 tons, or 8.8 per cent, while the value of the coal produced increased from $145,881,000 to $364,243,000.

Don't blame your coal dealer if your coal refuses to burn. His slate is clean.—*N. Y. Life.*

Pulverized Anthracite and Recovery of River Coal

Use of pulverized anthracite and the recovery and use of river coal were the subjects discussed at a meeting of the Engineers' Club, Philadelphia, Friday evening Dec. 3. Joseph A. Stienmetz, past president of the club, presided and called upon Dr. George Ashler, Pennsylvania State Geologist, to tell of the resources of river coal, which is found in the rivers and their tributaries in the anthracite regions. It is washed into the rivers by the discharge from the washers at the mines and is carried long distances down the river, especially during high-water periods, and deposited on the river bottom. In many cases the tributaries of the river have become practically filled with this class of coal, even to the extent of causing these streams to overflow their banks and spread out over the adjoining lowland. Much of this coal is of grades known as rice and barley, although large quantities are little more than dust. For a number of years this coal has been reclaimed on a small scale, but within the past four or five years its reclamation has reached large proportions, amounting to 2,000,000 tons in 1919. One of the largest sources of this coal is the Susquehanna River around Harrisburg, where about 750,000 tons is recovered annually. Practically all coal used in Harrisburg for industrial power purposes and by the power companies is pumped from the river. During recent years large quantities have been taken from the tributaries of the river, and this is the source of the best coal.

Dr. Ashler was of the opinion that at the present rate of mining there was river coal enough in sight, without any more coming into the rivers, to last four or five and possibly ten years. This will be added to as the dumps at the mines are worked over so that there may be a possible 25,000,000 tons; therefore it is only a mere incident in the power problem.

Mr. Edwards Takes Exception to Dr. Ashler's Estimate

J. P. Edwards, who was the second speaker, took exception to Dr. Ashler's estimate for the total available tonnage of river coal. From Mr. Edwards' experience he estimated that river coal of the rice and barley grades was being deposited at the rate of 8,000,000 tons a year. He told of one of his reclamation stations on a river tributary where the coal was deposited ten feet deep. Here a crane was installed on the bank to operate a 1½-cu.yd. clamshell bucket. It has only a 25-ft. digging radius, but in three years has removed 140,000 tons of coal from this space—the coal coming in practically as fast as it is removed. It was Mr. Edwards' opinion that the supply of river coal was practically self-perpetuating and that the possibilities had only been scratched. River coal is of much better grade than many of the sources of supply and can be obtained at less than half the cost of bituminous coal. A test made on river coal shows it to have a heat value as high as 14,000 B.t.u., although in general it will run around 11,000 to 12,250 B.t.u., with an ash content of 13 per cent. If care is not taken in preparing the coal, the ash content may run as high as 15 to 18 per cent.

G. R. Delamater agreed with Mr. Edwards that the supply of river coal was going to last much longer than most people think, although he was of the opinion that the supply of larger sizes was decreasing. He emphasized the necessity of equipping boilers to burn the smaller size of coal or even coal dust. He said he had seen river coal burn with only a 10 per cent ash content and that 14 per cent should be an average. In some cases the ash content was as high as 25 to 30 per cent, but this was only a question of removing the sand from the coal.

R. M. Vail, in discussing the different type of machines for pulverizing coal, expressed the opinion that anthracite, on account of its high abrasive qualities, could be most economically pulverized in some sort of a tube mill using balls for grinding. Success in grinding anthracite would be found in taking advantage of its brittleness and avoiding its abrasiveness, said Mr. Vail.

In discussing the burning of powdered anthracite, J. R. Wyllie told of obtaining over 400 per cent rating from boilers and of operating them for days at 300 per cent rating. He told of obtaining 19 per cent CO_2, but this was found very hard on the furnace, and he was of the opinion that 14 per cent CO_2 was about right for economical operation. He said that in burning powdered anthracite it was necessary that 90 per cent of the coal go through a 200-mesh screen, and each powdered-anthracite proposition has to be treated separately.

Briquets from Culm Coal

J. H. Kennedy discussed the making and use of briquets from culm coal. He said that a successful briquet must be waterproof; must be hard, not brittle; and must stand up in the fire while burning. Mr. Kennedy told of briquets being manufactured that contained 92 per cent culm and 8 per cent binder. This binder contained 12 parts water, 2 parts asphaltum and 1 part starch. Briquets, said the speaker, have been made for the past fifty years in Europe, but those used in Europe could not be sold in this country. One of the difficulties in burning briquets has been the use of too much draft. On account of the uniformity of the size of this fuel, it is necessary to cut down the draft considerably below that required for burning common grades of coal. The briquets that Mr. Kennedy described could be sold at the present times for $8 per ton f.o.b. factory.

W. W. Pettybone told of the experience of the Bethlehem Steel Co. at Lebanon, Pa., in burning pulverized coal. Four 520-hp. boilers are in operation, burning pulverized bituminous coal. A pulverizer used on bituminous coal for a number of years, was tried on anthracite, and after ten days' operation it was necessary to rebuild it. Nevertheless, Mr. Pettybone was convinced that pulverized anthracite could be burned successfully. It was found that a change could be easily made from burning pulverized bituminous to pulverized anthracite and vice versa. When burning grades of coal ranging from 11,000 to 13,000 B.t.u., over-all boiler efficiencies were obtained ranging from 82 to 87 per cent, with a monthly efficiency averaging a little better than 80 per cent. No trouble has been experienced when operating the boilers at 200 per cent rating; above 200 per cent difficulty is liable to be encountered with the brickwork. Although it is possible to obtain 17 per cent CO_2, it has been found that the highest efficiencies are developed with 10 to 11 per cent.

H. D. Savage expressed the opinion that there is no greater difficulty in burning anthracite at high boiler rating than in burning bituminous, but it cannot be burned so successfully for low and intermittent ratings.

"Turbine" Boiler Furnace

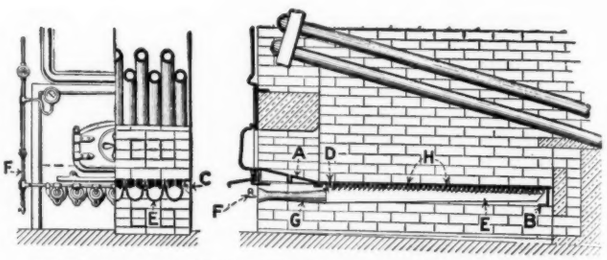
If the air flow into a furnace is uniform and the fuel is spread evenly over the grate, combustion will also be uniform and even throughout the whole area of the fire. In an ordinary boiler furnace these conditions are not necessarily fulfilled, resulting in an excessive air flow through the grate, which is a particularly active source of loss. By the use of the furnace herewith described, it is claimed, says the London *Electrical Review*, that a considerable reduction in the amount of excess air can be made, the air can be thoroughly diffused over the whole area of the grate, and it can be brought everywhere into intimate contact with the fuel.

The furnace under consideration takes its name from the analogy which its form in longitudinal section bears to the jet and blades of an impulse steam turbine, the intention being that the air shall pass up between the fire bars at an equal rate over the whole surface of the grate.

As shown in the illustration several troughs (the number varies with the width of the furnace) rounded at the bottom and measuring about 5 in. across their mouths are disposed longitudinally in the furnace. Each trough is separate from the rest and lies, unbolted, in contact with its neighbors, being hooked at either end over ridges on the dead and bridge plates *A* and *B*, but otherwise unsupported. Angle-sectioned extension pieces *C* are bolted to the two outer troughs so as to fill the gaps between them and the furnace walls.

Within the mouths of the troughs are placed fire-bar members *H* so that each trough has, say, three or four dozen of these separate fire-bar castings, which are supported on the edges of the troughs. Each casting is provided with a slot in front and with a flat web behind which fits into the slot of the succeeding casting. It will be appreciated, then, that the fire-bar castings can be rapidly slid into position, the whole being locked together by the insertion of the last member *H*.

The top surface of the grate thus formed is, however, not continuous; between each pair of castings a ¼-in. wide slot is left for the passage of air from the trough below, the width of the slot being preserved even when the castings are tightly pressed together. The rear face of the blade of each casting lies at an angle of 45 deg. to the general top



"TURBINE" FURNACE APPLIED TO A WATER-TUBE BOILER

surface of the grate; the forward face of the succeeding casting makes an angle of 60 deg. with the same plane, and the ¼-in. slot between the pair is thus continued below in the form of an inclined tapered passage. It is this form of air passage, it is claimed, which enables the finest fuels (even in a powdered form) to be burned, because the inclined surfaces tend to prevent the fuel falling through the slots between the fire-bar members. As shown at *E*, the bottom edges of the sloping blades are formed to a radius so that with the curved bottom of the trough they make an approximately circular passage for the air flowing along the trough. The area of this passage, owing to the inclined trough bottom, the trough being shallower toward the back than at the front, decreases from back to front in such a way that, as air escapes through the successive slots into the fire, the velocity of the remainder in the trough remains constant.

Air is drawn into the troughs by means of a separate steam jet *F*, for each trough, which is placed at the mouth of an injector pipe *G*. For the first portion of their length the injector pipes contract in diameter, for the center portion they are parallel, and for the remaining portion they expand to suit the radius of trough bottom, as shown at B.

All the steam jets are connected to a single source of steam; the nozzles have a large coefficient of expansion, and their form is such that the jet of steam splays out and fills the bore of the injector pipe. Superheated steam is used for the jets. The supply is taken from the top of the boiler and led by a system of piping through a reducing valve and pressure gage for some distance into the side flue before passing to the jets. This form of superheater is very simple and easy to install, it being necessary to remove a single brick only from the boiler setting. The employment of superheated steam, it is claimed, increases the efficiency of the injector jets, because for equal weights the volume delivered is greater if superheated. Further, the use of a number of small jets also leads to economy, for the amount of steam used is proportional to the square of the jet diameter. The air pressure prevailing in the troughs depends on the pressure of the steam delivered to the jets. Therefore, the air pressure below the fire bars can be regulated over a considerable range, so that a wide variety of fuel can be burned in a furnace at different times. The ash and clinker are removed by raking them out over the dead plate *A*. Very little dust falls through the bars into the troughs; what does is removed by a long-handled scoop. "Turbine" furnaces can be readily fitted to any type of boiler.

The Constitution and Properties of Boiler Tubes*

BY ALBERT E. WHITE
Consulting Metallurgical Engineer, Professor of Chemical Engineering, University of Michigan

DURING the winters of 1913-14 and 1914-15 the necessity of frequent boiler-tube replacements in the Park Place heating plant of the Detroit Edison Company resulted in considerable difficulty in maintaining continuity of boiler operation. This trouble, brought to a climax by the failure of a tube in No. 7 boiler in June, 1915, led to investigations to determine the causes of, and suggest remedies for, boiler-tube deterioration. Investigations were started along three lines: (a) Water softening, (b) rearrangement of baffling, and (c) considerations relating to the composition and constitution of boiler tubes.

In practically all tubes removed a thin calcium sulphate scale was found. The feed water contained very little of this salt, but owing to extended periods of overload and to the fact that 98 per cent of the feed was raw water from the city mains water softening was deemed necessary. After considerable research it was decided to treat all the water with soda ash in live-steam purifiers. This treatment has been successful, the flocculent sodium carbonate and soluble sodium sulphate being taken care of by frequent boiler blowoffs.

The fact that the front tubes were particularly prone to develop defects led to the study of baffling conditions. Originally the front baffles were between the first and second rows of tubes (the boilers were of the Stirling type). To distribute the effect of radiant heat the baffles were placed between the second and third tube rows. This resulted in materially lowering tube replacements without decreasing fuel economy or increasing smoke nuisance.

In investigating the constitution of the tubes a number of samples were examined metallographically. The photomicrographs indicated generally that the constituents were evenly dispersed, although there was evidence of phosphorous segregation and in many cases cavities or segregations were evident.

As a result of his studies the author lists the principal causes of tube failure in general (excluding that due to scale formation) as follows: (a) Tube brittleness due to absorption of hydrogen, usually attributable to faulty feed water treatment; (b) blowholes and imperfections in the metal, attributable to steel-mill conditions; (c) recrystallization of the metal.

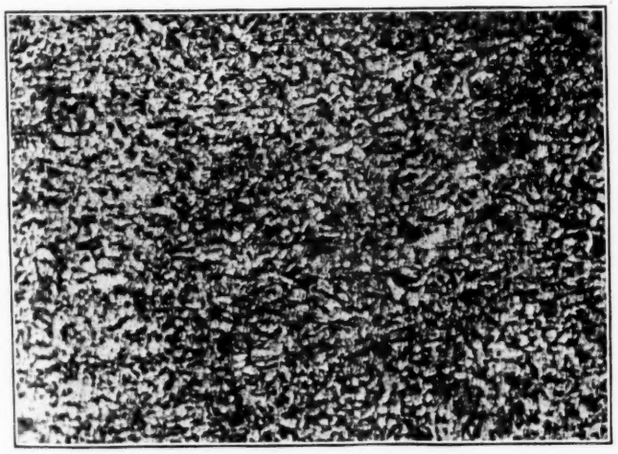


FIG. 1. PHOTOMICROGRAPH OF DEFORMED STEEL BEFORE BEING HEATED

The matter of recrystallization merits much consideration. This will occur if steel with a low carbon content, which has previously been mechanically deformed at a temperature below the critical, is later heated for a sufficient time to any temperature below that at the critical. The common composition for boiler tubes is such that this type of metal is especially susceptible to this phenomenon. In modern mill practice tubes are straightened and often actually brought to final size below the critical temperature. Tubes are often bent during fabrication and erection and are universally rolled into the tube sheet when cold. Methods of cleaning tubes often produce local deformation by repeated hammer blows. Finally, the time and temperature conditions required for recrystallization are present.

FIG. 2. PHOTOMICROGRAPH OF DEFORMED STEEL AFTER HEATING AT 650 DEG. C. FOR 15 HOURS

The growth of crystals occurs more rapidly the higher the temperature to which the metal is heated. Experiments for a certain set of conditions led to the following formula:

$$T = 8 \times 3^n$$

where T = time in minutes for a certain crystal growth; $n = (675 - t) \div 25$; and t = temperature in degrees centigrade. These experiments covered a range of 550 deg. C (1,022 deg. F.) to 675 deg. C (1,247 deg. F.).

Fig. 1 is a photomicrograph of a tube specimen which has been deformed, and Fig. 2 shows a similar specimen after being heated at 650 deg. C. (1,202 deg. F.) for 15 hours. The increased size of the grains in Fig. 2 shows clearly the crystal growth.

To determine the physical properties due to crystal growth tension and fatigue tests were made on (a) metal "as received," (b) metal annealed for 10 minutes at 950 deg. C. (1,742 deg. F.) and then cooled in the furnace, and (c) on "coarse-grained" metal produced by stressing the specimens beyond the elastic limit and then annealing for three hours at 800 deg. C. (1,472 deg. F.).

The physical properties of the "as received" specimens showed satisfactory metal. The average tensile-strength and elastic-limit values of the "coarse-grain" samples were 27.2 and 58.9 per cent respectively, lower than those of the "as received" samples. In the fatigue tests the "coarse-grain" metal was 16.2 per cent poorer than the "as received" samples and 48.70 per cent poorer than the "annealed metal."

In view of this the question arises as to the possibility of improving the constitution of the metal by using a composition that is as easy to produce, as easy to install, as resistant to the absorption of hydrogen, stronger, as free or freer from blowholes, and above all, less subject to recrystallization. It is suggested that these conditions might be met by steel with a carbon content of 0.30 to 0.35 per cent better than by steel with 0.08 to 0.18 per cent carbon.

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, in New York City, December, 1920.

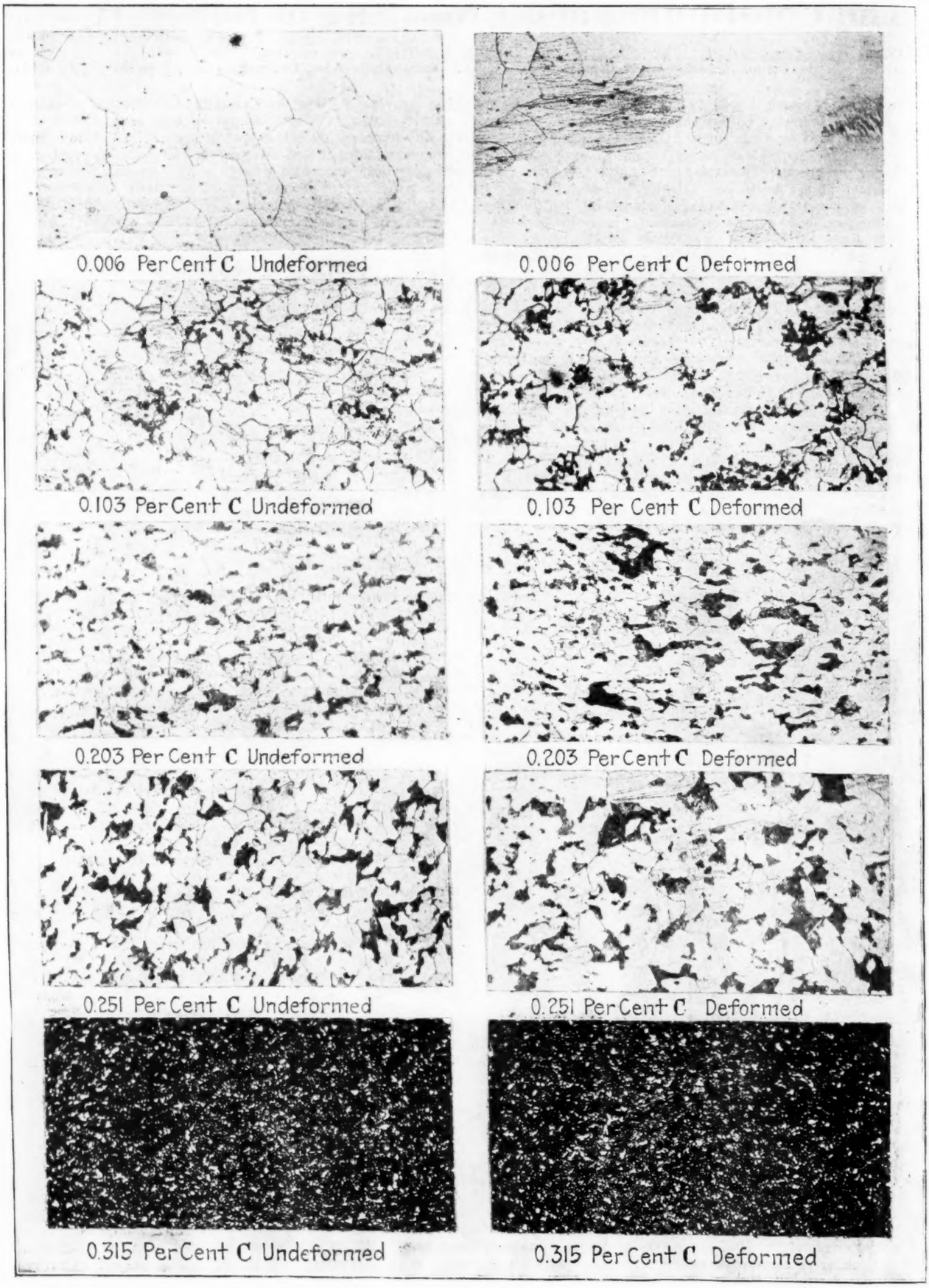

0.006 Per Cent C Undeformed
0.006 Per Cent C Deformed
0.103 Per Cent C Undeformed
0.103 Per Cent C Deformed
0.203 Per Cent C Undeformed
0.203 Per Cent C Deformed
0.251 Per Cent C Undeformed
0.251 Per Cent C Deformed
0.315 Per Cent C Undeformed
0.315 Per Cent C Deformed

FIG. 3. PHOTOMICROGRAPHS SHOWING EFFECT OF CARBON CONTENT ON GRAIN GROWTH WHEN DEFORMED STEEL IS HEATED BELOW ITS CRITICAL TEMPERATURE

The higher-carbon tubes will not be appreciably more difficult to make or install, and there is nothing to indicate that they will absorb hydrogen more readily. It should be possible to make them as free from blowholes and they will be at least 40 per cent stronger in respect to tensile strength and elastic limit with no detrimental decrease in elongation or reduction.

To secure evidence of the effect of the carbon content on recrystallization, tests were made on five specimens, ranging from 0.006 to 0.315 per cent carbon. Each sample was annealed and then impressed with a 5 mm. ball under a load of 3,000 deg. The samples were afterward heated for four hours at 675 deg. C. (1,247 deg. F.) and then examined to compare the average grain size in the undeformed portion and in that part of the deformed portion showing the maximum grain size.

TABLE I. EFFECT OF CARBON CONTENT ON GRAIN GROWTH WHEN DEFORMED STEEL IS HEATED BELOW ITS CRITICAL TEMPERATURE

Carbon Content, per Cent	Number of Ferrite Grains per Sq.In. Undeformed	Deformed
0.006	3.9	1.9
0.103	25.4	13.4
0.203	63.4	23.0
0.251	26.3	16.0
0.315	(a)	(a)

(a) Grains too small to count. Photomicrographs from both the undeformed and deformed areas show no appreciable difference in grain size.

The results in Table I and the micrographs in Fig. 3 indicate a perceptible grain growth for the carbon range from 0.006 to 0.251 per cent, while no visible change appears with 0.315 per cent carbon.

TABLE II. SERVICE TEST ON MEDIUM, HIGH- AND LOW-CARBON BOILER TUBES AT PARK PLACE HEATING PLANT, DETROIT, MICM.

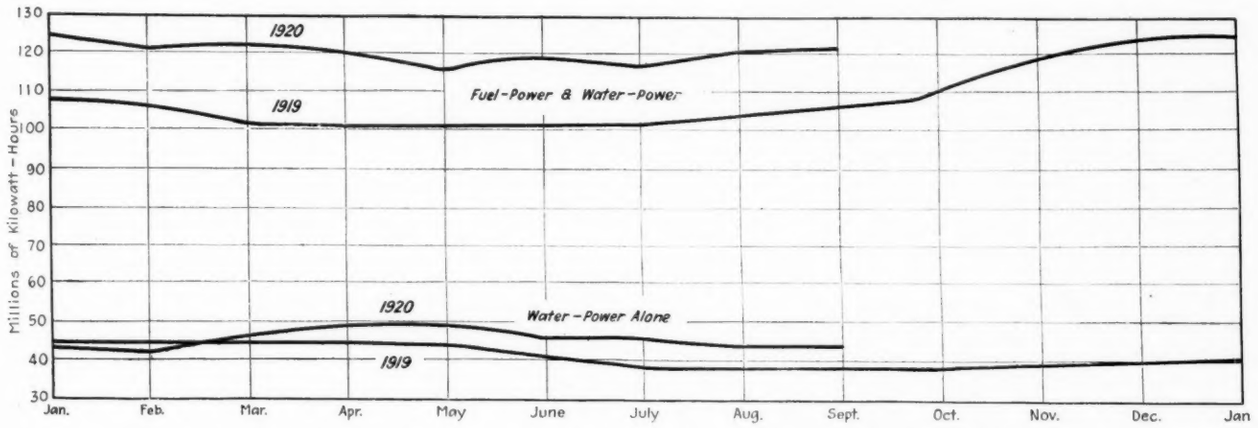
Boiler Number	Installation Number	Installation Date	Replacement Number	Replacement Date
High-Carbon Tubes in Front Row				
3	29	June 19, 1916	27	July 27, 1918
			15	Summer, 1920
6	29	May 9, 1916	13	Sept. 11, 1917
			5	July 15, 1919
			1	Summer, 1920
7	29	June 19, 1917		
8	29	June 9, 1917		
Totals....	116		61	
Low-Carbon Tubes in Front Row				
1	29	Sept. 23, 1916	27	July 12, 1918
			5	Summer, 1920
2	29	Sept. 18, 1916	10	Sept. 28, 1917
			27	July 11, 1920
			7	Summer, 1920
4	29	June 14, 1916	18	Jan. 6, 1917
			5	July 27, 1918
			13	June 17, 1919
			5	Summer, 1920
5	10	June 5, 1916		
	19	Aug. 3, 1917	10	Aug. 3, 1917
Totals,	116		127	

To compare these theoretical results with those under service conditions tubes averaging around 0.30 per cent carbon were installed in the front rows of four of the 750-hp. Stirling boilers at the Park Place heating plant in Detroit, while four other boilers were equipped with front-row tubes ranging between 0.08 and 0.18 per cent carbon. The results of this test are given in Table II and speak for themselves.

The author does not criticize present boiler-tube manufacturing practices, which, all things considered, are on a high quality plane. He does, however, wish to present certain facts and to question whether tubes with a carbon content of 0.30 to 0.35 per cent would not insure longer tube life and safer boiler operation than tubes having 0.08 to 0.18 per cent carbon.

Production of Electric Power in the United States

As shown by the accompanying chart, the average daily production of electricity in kilowatt-hours by public-utility plants in the United States for the first nine months of 1920 was as follows: January, 124,700,000; February, 119,800,000; March, 120,700,000; April, 119,100,000; May, 115,600,000; June, 118,800,000; July, 117,000,000; August, 119,700,000; and September, 120,200,000. The proportion of each monthly total produced by water power was, respectively, 33, 33, 38, 41, 42, 40, 38, 37 and 37 per cent. The total output of electricity in this time was 28,341,000,000 kw.-hr.; this was 15.5 per cent greater than the output for the corresponding period of 1919. The amount of fuels consumed by these public-utility companies in this nine months' period of 1920 was: Coal, 27.7 million short tons; fuel oil, 9.9 million barrels; gas, 18.2 billion cubic feet.



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITY PLANTS IN THE UNITED STATES OBTAINED BY DIVIDING THE TOTAL FOR THE MONTH BY THE NUMBER OF DAYS IN THE MONTH

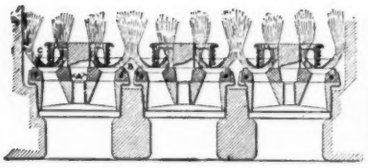
These figures are based on returns received by the Geological Survey from about 3,000 power plants of 100-kw. capacity or more, engaged in public service, including central stations, electric railways and certain other plants which contribute to the public supply. The capacity of plants submitting reports of their operations is about 94 per cent of the capacity of all plants listed; consequently the figures may be regarded as conclusive.

Applications covering 7,726,651 hp. had been submitted to the Federal Power Commission at the close of business Nov. 20. This greatly exceeds the most optimistic estimate made prior to the passage of the Water-Power Act. That estimate will be exceeded by 400,000 hp. if the treaty is modified so as to permit the diversion of 20,000 sec.-ft. additional from the Niagara River. The projects on navigable streams involve 4,790,350 hp. and those on public lands and reservations 2,936,501 hp.

Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Valve, Duplex Unaflow Pumping Engine Water
Worthington Pump & Machinery Corp., New York City
"Power," Nov. 9, 1920



This pump valve consists of a soft-rubber valve seat reinforced by a copper ring. The metal valve is made saucer-shape, with a spring pressure on one side working against the water pressure on the other. The discharged water not only escapes past the outer edge but also finds a passageway through the opening between the outer and center portions of the valve. The valve seat is tapered, and the water is discharged past the valve at an easy angle, which reduces the friction.

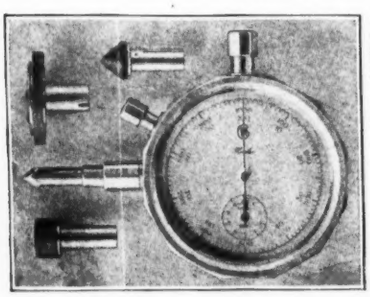
Hoist, Telescopic, Ash
Gillis & Geoghegan, 537 West Broadway, New York City
"Power," 1920

Several types of telescopic hoists are made, "Type D" being designed for handling ashcans from basements and unloading into wagons. This hoist is electrically operated, and the upper part of its telescope is below the grade when not in use. It will raise a load of 300 lb. at a speed of 60 ft. per min. and is designed to raise loads of 6 or 7 ft. above grade, and as much as 3 ft. away from the hoistway, thus permitting of dumping into an ash cart. The steel cable used is non-rotating, which eliminates twisting. The machine is equipped with an automatic stop and gravity lowering device.

Dynamobile, Ludlum
New York Engineering Co., 2 Rector St., New York City
"Power," Oct. 26, 1920

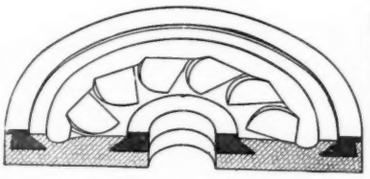
This machine consists of a water-tube marine-type boiler, a steam turbo-generating unit, switchboard, boiler-feed pump, feed-water heater, condenser, and where the highest economy is desired, a superheater. All are set on a steel frame mounted on wheels. The outfit can be furnished for burning any kind of fuel. It is built in 10-kw. capacity up to 220-kw., either alternating or direct current.

Indicator, Hasler Speed
C. H. Boulin, 82 Duane St., New York City.
"Power," 1920



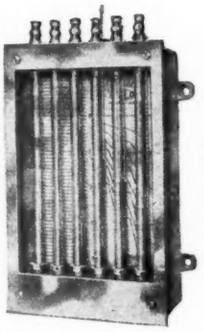
This integrating tachometer counts the speed over a period of three seconds and then "integrates" the results to give the desired information in terms of revolutions per minute or yards per minute. No watch is needed, as the timing is obtained automatically. Once the contact is made with a shaft the spindle of the instrument runs freely until a large button is pressed and released. This makes direct connection with the hands on the dial. After running for three seconds the spindle is automatically freed and the hands remain in the reading position. After the reading has been taken the hands may be brought back to zero by pressing a button. The instrument has a speed ranging from one to 10,000 r.p.m.

Valve, Norbom Rotating Pump
Norbom Engineering Co., Darby, Pa.
"Power," 1920



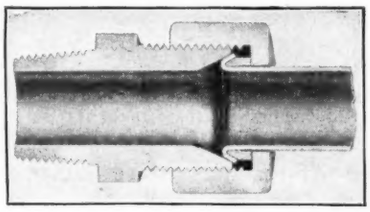
This valve consists of a light and strong alloy body and a special soft-metal face where it comes in contact with the valve seat. This lining will not break and is not affected by oil, cold or hot, acids or alkali water. The under surface of the valve is cast with turbine veins, which cause it to rotate, thus wearing the soft-metal lining evenly. When worn the lining can be renewed.

Multigage, Philo
Schumacher-Santry Co., 141 Mills St., Boston, Mass.
"Power," Nov. 23, 1920



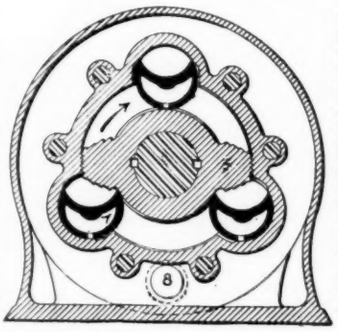
This gage consists of six tubes into which the liquid flows and which connects with a storage tank that is filled to the zero mark on the scale with special gage oil having a specific gravity of 0.89. The six tubes are placed so that a careful comparison of each reading with any other may be obtained. With conditions running normally, the height of the liquid in the various tubes form a certain curve. Any variation in the characteristics of this curve caused by a too heavy fire on parts of the grate or by blowholes will immediately tell the fireman how to adjust conditions.

Union, Reilly Screwed
Griscom Russell Co., 90 West St., New York City
"Power," 1920



The heating surface of the Reilly heater consists of interchangeable coils which are attached to the top and bottom manifolds by screwed union joints. It it is a metal-to-metal joint and eliminates any possibility of leakage and also facilitates the easy removal of the coils. This construction obviates the necessity for brazing, and every coil and union is standard and interchangeable. This type of joint makes a tight connection and is an assurance against breaks.

Engine, "High Speed" Steam Rotary
High Speed Engine Corporation, Union Bldg., Newark, N. J.
"Power," 1920



This engine, of the rotary type, has but four working parts, a shaft with a motor mounted thereon and three rolling abutments. It has no packing stuffing boxes or rubbing surfaces, and all parts are carried on ball bearings. Steam is used expansively, and as the steam receives a cutoff from one rotor piston the one on the opposite side receives a steam impulse before the first one is completed, so there is no idle point in the cycle. The length of the stroke or the amount of steam admitted can be controlled by a ring valve, of which there are three, by a central pinion to a segment.

Clip, paste on 3 x 5-in. cards and file as desired

New Publications

POWDERED COAL AS A FUEL. By C. F. Herington. Published by D. Van Nostrand Co., New York. Second edition; 303 pages; 124 illustrations. Price, $4.50.

The author, who has had a very extensive experience in the burning of pulverized coal, in this volume discusses the several problems encountered and the various pieces of machinery used in powdered-coal plants. The book is well written and covers the field more thoroughly than do other similar volumes. Unfortunately, the field is so broad that insufficient space is given to the several applications, such as power generation, steel furnaces, and other industrial processes. Owing to the increasing adoption of pulverized-coal equipment in boiler plants, the power plant engineer is very much interested in this form of fuel. The engineer will find considerable information here which applies to boiler use. The author points out one prevailing misconception. He states that while a poor coal can be burned successfully when pulverized, there is a limit to the quality that can be used. Furthermore, he states that it is hardly possible to use anthracite culm, concerning which much has been written of recent years. It is unfortunate that more actual operating data are not given; most of the coal figures listed are estimates. In these estimates he rather inclines to underestimate the labor required, which considerably exceeds that required by a stoker fired or an -oil burning boiler plant. The power engineer will find the volume well worth his while, since it gives him the best available information on pulverized coal.

Society Affairs

The Akron Section of the A. S. M. E. will hold a meeting on Dec. 17, at which E. S. Carman, the president-elect of the society, will speak.

The American Society of Safety Engineers will hold a joint meeting with the New York Chapter of the National Fire Protection Association at 8 p.m., Dec. 17, in the Engineering Societies Building, New York City. The program will include papers, moving pictures and general discussion of the subject of safety from fires.

The Boston Section of the A. S. M. E. will meet on Dec. 17. The speakers will be H. J. Barrows and W. S. Murray, and their subjects will be "Water Power of New England."

The Pittsburgh Section of the Association of Iron and Steel Electrical Engineers will hear an address on "Electric Welding," by Gordon Hughes, of the Truscon Steel Co., Youngstown, Ohio, on Dec. 18.

The Buffalo Section, A. S. M. E., will meet at the University Club on Dec. 21 to hear a talk by C. F. Collins, of the General Electric Co., on "Industrial Applications of Electric Furnaces."

The Engineer's Society of Western Pennsylvania will meet in the William Penn Hotel, Dec. 14. G. G. Bell, of the West Penn Power Co., will read a paper entitled "Steam vs. Electric Driven Power-House Auxiliaries"; the paper will be illustrated by lantern slides.

The Engineering Society of Western Massachusetts will meet at 8 p.m., Dec. 14, in the Holyoke High School, Holyoke, Mass. There will be presented a motion picture on "The Story of Petroleum," which was prepared by the Bureau of Mines. Prof. Charles M. Allen, of the Worcester Polytechnic Institute, will speak on "Uses and Abuses of Gasoline, Kerosene, etc."

Personals

Ray Mayhew recently motor engineer with the American Hoist and Derrick Co., St. Paul, has taken a position with the Clyde Iron Works, Duluth, Minn.

John B. Matthews, consulting engineer and surveyor, San Francisco, is now designing the first large turbo-electric driven passenger and cargo steamer to be built on the Western coast, and will have entire supervision of its construction.

W. R. Webster has resigned his position as assistant chief engineer for the Cambria Steel Co., Johnstown, Pa., to become general engineer of the Semet-Solvay Co., of Syracuse, N. Y.

Albert H. Hopkins has resigned from the presidency of the Engineering Advertisers' Association of Chicago, and from the managership of advertising and sales promotion departments of the C. F. Pease Co., Chicago, to become Chicago manager of the J. Roland Kay Co., Chicago, international advertising agents. Mr. Hopkins has been succeeded as president of the Engineering Advertisers' Association of Chicago by J. J. Arnsfield, advertising manager of the Fairbanks, Morse & Co. of Chicago.

Business Items

The Yarnall-Waring Co., of Philadelphia, Pa., has placed upon the market in this country, the Lea coal meter for use with chain-grate stokers. This instrument was first handled by the Lea Recorder Co., Ltd., Manchester, England, and was described fully in the Sept. 16, 1919, issue of *Power*.

The Metal and Thermit Corporation, New York City, has opened a branch office at 141 Milk St., Boston, under the direction of the New England district manager, Robert L. Browne. Inquiries will be answered from this branch office, but orders should continue to be addressed to the general office at 120 Broadway, New York City.

Trade Catalogs

The Cooper Hewitt Electric Co. has ready for distribution two bulletins: No. 86, "Cooper-Hewitt Quartz Lamp Laboratory Outfit," and No. 102, a technical bulletin on the Cooper-Hewitt Quartz Lamp and Ultra-Violet Light. The latter contains scientific data and a short bibliography which should be useful in a study of this form of lighting.

The Elliott Co., manufacturer of power accessories, Jeanette, Pa., has received from the printers a new catalog "C" of forty-eight 7 x 10-in. pages. This catalog contains descriptions and pictures on the company's line of jet and surface condensers, together with a good deal of useful, practical information on condensers in general.

COAL PRICES

Current mine quotations, with interesting comparisons, are given in the following tabulation:

	Nov. 1919*	Aug. 5 1920	Dec. 2 1920	Dec. 9 1920
Pittsburgh steam	$2.30	$10.00	$5.00	$4.00
Pittsburgh screened gas	2.30	12.00	5.50	4.75
Hocking	2.50	9.00	4.50	4.25
Franklin, Ill	2.35	6.50	5.00	5.00
Indiana 4th vein	2.35	7.50	4.00	4.00
Eastern Ohio, No. 8	2.35	10.50	5.00	4.50
Fairmont	2.50	13.50	4.75	4.25
Kanawha	2.60	14.00	4.75	4.50
S. E. Kentucky	3.00	10.50	5.25	5.25
Western Kentucky	2.35	5.25	4.25	4.25
Clearfield	2.95	12.00	5.00	4.75
Cambria and Somerset	2.95	13.50	6.00	6.00
New River	2.70	14.00	5.25	5.25
Pocahontas	2.35			

*Government prices.

Tidewater dumpings in the week of Nov. 27 were 1,034,000 tons, a decrease from the preceding week of 107,000 tons, according to the Geological Survey. The decline was due largely to the falling off of exports, which amounted to 399,000 net tons, as against 532,000 tons for the week before. Foreign shipments were less than 60 per cent of those during the record week of Oct. 17, when exports were at the rate of over 2,900,000 tons per month.

New Construction

PROPOSED WORK

Mass., Boston—The Chamber of Commerce, 177 Milk St., is receiving sketches for a 12 story, 100 x 184 x 184 ft. office building at Federal, Franklin and Congress Sts. About $6,500,000. Archt. and Engr. not selected.

Mass., Boston—The City Hospital, Dr. J. Dowling, Supt., plans to build a 3 story, 60 x 125 ft. hotel on East Concord St. About $350,000. Maginnis & Walsh, 100 Boylston St., Archts.

Mass., Dorchester (Boston P. O.)—The Schoolhouse Dept., City Hall Annex, Boston, had plans prepared for a 3 story junior high school including a steam heating plant on Roger Wolcott St., here. About $400,000. H. H. Atwood, 61 Alban St., Boston, Archt.

Mass., Pittsfield—The Pittsfield Electric Co., 92 Renne Ave., plans to build an addition to power plant. Between $100,000 and $125,000.

Mass., Woods Hole—The Dept. of Commerce, Bureau of Fisheries, Washington, D. C., will receive bids until Dec. 28 for the construction of a boiler and storage house at the fisheries station here.

R. I., Pawtucket—The Hope Webbing Co., 1005 Main St., plans to build a 5 story, 80 x 198 ft. addition to factory and a 1 story, 20 x 30 ft. boiler house. About $300,000. Perry & Whipple, R. I. Hospital Trust Bldg., Engrs.

Conn., New Britain—The School Comn., F. N. Gaffney, Chn., plans to build a state normal school. About $1,000,000. Guilbert & Betelle, 665 Broad St., Newark, N. J., Archts.

Conn., New Britain—The State School Board, State Capitol, Hartford, wants sketches for a state normal school and dormitory, here. About $900,000.

Conn., Putnam — The Nightingale-Morse Mills plans to build a wheel pit, install water wheels and are also in the market for machinery. Lockwood-Greene & Co., 60 Federal St., Boston, Mass., Archts. and Engrs.

N. Y., Brooklyn—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install a refrigerating system for Building "F," here.

N. Y., Cadyville—The International Paper Co., 30 Broad St., New York City, is having plans prepared for a hydro-electric plant on the Saranac River, here. About $250,000. A. H. White, c/o company, Engr.

N. Y., New York—The United Electric Light & Power Co., 130 East 15th St., will soon receive bids for a transformer station on West 97th St. About $150,000.

N. Y., Rochester—Tatlock Bros., 183 Tremont St., are in the market for one 50-hp. marine boiler.

N. J., Madison—The Bd. Educ. is having plans prepared for a high school. About $300,000. Guilbert & Betelle, 665 Broad St., Newark, Archts.

N. J., Maurer—The Barber Asphalt Paving Co., Land Title Bldg., Philadelphia, Pa., will receive bids until Dec. 20 for machinery and manufacturing buildings and a power house, here. About $1,000,000. Lockwood-Green & Co., 101 Park Ave., New York City, Archts. and Engrs. Noted Nov. 23.

N. J., Ridgewood—The Continental Paper Box Co., 122 Washington St., Brooklyn, N. Y., will soon award the contract for a 2 story, 100 x 500 ft. factory including a steam heating system at Grand and Hall Sts., here. About $250,000. W. B. Wills, Inc., 1181 Myrtle Ave., Brooklyn, N. Y., Archt. and Engr.

Md., Baltimore — Louis Hurwitz, 248 Equitable Bldg., plans to build an 8 story, 45 x 200 ft. office building at 219 Courtland St. About $500,000. J. Freund, 1307 St. Paul St., Archt.

Md., Baltimore — The City Council had plans prepared and will soon receive bids for a 3 story, 125 x 150 ft. school at 33rd St. and Hillen Rd., including a steam heating plant. About $350,000. C. N. Friz, 2010 Lexington Bldg., Archt., C. L. Reeder, Park Ave. and Saratoga St., Engr.

D. C., Washington—The Treasury Dept., Supervising Architect's Office, will receive bids until Dec. 23 for a boiler house and extending outside light and power feeders at the United States Public Health Service Hospital No. 32, 2650 Wisconsin Ave.

S. C., Charleston—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., will receive bids until Dec. 29 for boiler plant improvements here. Noted Sept. 7.

Ga., Savannah—The Georgia Ice Co. will soon award the contract for a 2 story, 60 x 150 ft. addition to ice plant. One hundred ton ice making machinery will be installed in same. About $35,000. A. M. Dixon, P. O. Box 1352, Mgr.

Fla., Palatka—The United Sugar Corp., 1512 Walnut St., Philadelphia, Pa., is receiving bids for a sugar refinery including

12 buildings, spur track, etc., here. About $1,000,000. G. P. Anderson, c/o above address, Engr.

Ky., Louisville—The Ewald Iron Co., 324 North Clay St., plans to enlarge its present plant. About $3,000,000.

Ky., Louisville—The National Candy Co., 829 South Floyd St., plans to build an addition to present plant. About $1,000,000.

O., Cincinnati—The Cincinnati Gas & Electric Co., 114 West 6th St., is considering plans for the installation of a fourth generating unit. C. D. Jones, Pres.

O., Cincinnati—B. Heidingsfeld, Agt., 1406 Union Trust Bldg., has obtained option on site at McMillan and Manlose Aves. for a 145 x 300 ft. theater. About $500,000.

O., Cleveland—LaRoth-Keller Co., c/o H. Laronge, 10405 Parkgate Ave., N. E., purchased a site at the southwest corner of West 2nd St. and St. Clair Ave. for a 12 story, 146 x 166 ft. commercial building. About $1,500,000. Archt. not selected.

O., Cleveland—B. F. Keith, c/o Rapp & Rapp, 190 North State St., Chicago, Ill., is having plans prepared for a 21 story, 132 x 300 ft. theater and office building including a high pressure steam plant. About $3,500,000.

O., Columbus—The Northern Ohio Traction & Light Company, Akron, plans to build an electric power plant along the Muskingum River, 70 miles from here, to generate an initial capacity of 100,000 kw. Total est. cost, $15,000,000.

O., Youngstown—Strauss-Hirshberg Co., West Federal St., plans to build a 6 story, 300 x 300 ft. store building. About $2,000.000.

Mich., Battle Creek—The Bd. Educ. will receive bids about Jan. 1 for a 3 story, 75 x 400 ft. vocational school including a steam heating system. About $400,000. J. D. Chubb, 109 North Dearborn St., Chicago. Ill., Archt.

Mich., Detroit—The Fellowcraft Club, c/o F. E. Holmes, Washington Blvd., purchased site on Second Blvd. and will have plans prepared for an 8 story, 150 x 207 ft. club house including a steam heating system. About $2,000,000. Architect's name withheld.

Mich., Detroit—The Detroit Federation of Labor, c/o F. X. Martel, 77 East Adams St., plans to build a 10 story temple and office building including a steam heating plant on East High St. About $300,000. Archt. not selected.

Mich., Detroit—The League of Catholic Women, 47 Watson St., plans to build a 4 story, 120 x 140 ft. memorial clubhouse on Parsons St. About $500,000. Steam heating equipment will be installed in same. Archt. not selected.

Mich., Port Huron—C. Kern & Co. plans to build a 2 story electrically operated ice plant. About $100,000.

Ind., Crown Point—J. N. Coleman, Archt., 6257 St. Lawrence Ave., Chicago, Ill., will receive bids about Jan. 1 for several buildings including a 50 x 50 ft. power plant for The Crown Point Hospital, here. About $350,000.

Ind., Terre Haute—The Union Hospital, 7th and 8th Avenues, is having plans prepared for a 6 story, 44 x 200 ft. hospital including steam heating plant. About $300,000. Johnson, Miller & Miller, 105 South 7th St., Archts.

Ind., Valparaiso—The Pioneer Truck Co. is having plans prepared for a 2 story, 300 x 600 ft. factory including a steam heating system. About $500,000. Ronneberg, Pierce & Hauber, 10 South La Salle St., Chicago, Ill., Archts.

Wis., Kenosha—The Kenosha Ice Cream Co., 493 Elizabeth St., is having plans prepared for a 2 story, 46 x 75 ft. ice cream factory on Grand Ave. Refrigerating equipment will be installed in same. C. Augustine, Archt.

Wis., Kenosha—The Sheridan Hotel Co., c/o W. W. Ahlschager, Archt., 65 East Huron St., Chicago, Ill., will receive bids until about March 1 for a 10 story, 95 x 132 ft. hotel here, including a steam heating system. About $1,500,000.

Wis., Milwaukee—The Wisconsin Bed Spring Co., J. A. Mett, 968 Oakland Ave., plans to build a 1 or 2 story factory. Electric motors will be installed in same. Archt. not selected.

Wis., Watertown—The Badger Concrete Mixer Co., 221 Grand Ave., Milwaukee, plans to build a 1 story, 80 x 300 ft. factory, here. Electric power motors will be installed in same. Archt. not selected.

Wis., Wauwatosa—The N. W. Chemical Co., State St., is having plans prepared for an air washing system including air compressor, centrifugal pump, mechanical fan, etc. About $8,000. C. Ringer & Son, University Bldg., Milwaukee, Engrs.

Iowa, Cedar Rapids—Linn County plans an election Dec. 27 to vote on $1,300,000 bonds for a 3 story, 128 x 208 ft. court house and jail including a steam heating system. J. W. Royer, Urbana, Ill., Archt.

Minn., Mankato—The Bd. Educ., c/o E. F. Seering, Secy., is considering a bond issue for a 2 or 3 story junior high school including a steam heating system. About $300,000.

Minn., Minneapolis—The Minneapolis Library Board, D. D. Dayton, Secy., 10th St. and Hennepin Ave., has selected a site and plans to build a 2 or 3 story library including a steam heating system at Hennepin Ave. and Groveland Terrace. About $1,000,000. Archt. not selected.

Minn., Rush City—J. D. Markham and A. Kelsey, Benham, Wis., plan to build a power plant, dam, and a 7-mile transmission line across the St. Croix River here. About $2,000,000. Druar & Milinowski, 512 Globe Bldg., St. Paul, Engrs.

S. D., Oldham—The city has voted $25,000 bonds for improvements to the electric light system.

Mo., Kansas City—The White Co., East 79th St. and St. Clair Ave., Cleveland, Ohio, had plans prepared for a 3 story, 120 x 144 ft. auto service station including a steam heating system at 28th and Warwick Sts., here. About $250,000. Watson Engr. Co., Hippodrome Bldg., Cleveland, Ohio, Engrs.

Mo., St. Louis—The Jefferson Hotel Co., T. Hays, Mgr., 12th and Locust Sts., will receive bids until Jan. 15 for a 12 story, 50 x 200 ft. hotel. About $1,200,000. T. P. Barnett, Arcade Bldg., Archt.

Mo., Springfield—The Shrine Temple Bd. of Trustees, C. G. Mark, Secy., Landus Bldg., will receive bids until March 1 for a temple including steam heating system. About $250,000. Archt. not selected.

Ark., Springdale—The Welch Grape Juice Co. plans to build a factory. About $500,000. Archt. not selected.

Tex., Dallas—The Oliver Chilled Plow Wks., 811-13 Elm St., is having plans prepared and will receive bids soon after Jan. 1 for a 10 story, 142 x 200 ft. office and implement house. About $600,000. Lang & Witchell, Amer. Ex. Nat'l Bank Bldg. Archts.

Tex., Dallas—The Dallas Athletic Club, W. E. Greiner, Pres., is having plans revised and will receive bids after Jan. 1 for a 10 story office building including a heating system. About $1,000,000. Lang & Witchell, Amer. Ex. Nat'l Bank Bldg., Archts.

Tex., Denison—The Chamber of Commerce is receiving bids for a 5 story, 150 x 150 ft. hotel including a steam heating system at Woodord and Burnett Sts. About $400,000. E. E. Hall, 123 West Madison St., Chicago, Ill., Archt.

Col., Denver—The Medicos Bldg. Assn. had preliminary plans prepared for a 6 story, 125 x 150 ft. office building at 17th St. and Bway. About $1,000,000. W. N. Bouman, 914 Central Savings Bank Bldg., Archt. and Engr.

Idaho, Hailey—The Mascot Mining & Milling Co. plans to install a 700-hp. hydro-electric unit next spring. C. Peters, Pres.

Cal., Los Angeles—The city, in co-operation with the county of Los Angeles plans to build a 385 ft. high gravity dam to be known as the Pacoima Dam. Plans include a hydro-electric plant. About $1,500,000. J. W. Reagan, Court House, Engr.

Cal., San Bernardino—The city has retained F. C. Finkle, Consulting Engr., I. W. Heilman Bldg., Los Angeles, to make report and prepare plans for water and power development in Cajon Basin. Plans include the Mathew's Lake project, development of 1,000 hp., storage of 630 in. water, $733,000; and the Vincent Clenega project, development of 770 hp., storage of 590 in. water, $767,000.

Cal., Santa Ana—The city plans to build a reservoir on Santiago Creek, and a dam, 100 ft. high, to impound 7,000,000,000 gal. of water. W. W. Hoy, City Engr.

Ont., Brantford—The Bd. Educ. plans to build a 3 story technical school including a steam heating system. About $300,000. Archt. and Engr. not appointed.

Ont., Toronto—The city engineer, R. C. Harris, has submitted report of estimates for 1921 which includes the expenditure of $100,000 for the installation of boilers and generators at the Riverdale pumping station and $156,000 for generator and alterations at the Highland Station.

B. C., Ruskin—The Western Power Co. of Canada, 198 West Hastings St., Vancouver, has received a report submitted by Creer & Mackenzie, Engrs., 837 West Hastings St., Vancouver, in regard to raising the dam and installing an additional unit of about 13,000 hp. at Stave Falls, here.

Sask., Prince Albert—E. F. Webb, City Clk., will receive bids until Dec. 18 for one horizontal centrifugal pump, 1,400 Imp. g.p.m., 50-ft. head, direct-connected to a.c. electric motors; one pump as above without electric motor (alternative); one horizontal centrifugal pump with capacity and head as above direct-connected to steam turbine; one horizontal centrifugal pump, 1,400 Imp. g.p.m., 190-ft. head, direct-connected to a.c. electric motor; one horizontal centrifugal pump, 700 Imp. g.p.m., 190-ft. head, direct-connected to a.c. motor; one horizontal centrifugal pump, 1,400 Imp. g.p.m., 190-ft. head, direct-connected to steam turbine; two vertical centrifugal pumps, 500 U. S. g.p.m., 40-ft. head, suitable for sewage pumping, direct-connected to a.c. motor.

CONTRACTS AWARDED

N. Y., New York—M. Gold, c/o Gronenberg Leuchtag, Archts., 393 5th Ave., will build a 7 story office building including a steam heating system at 127-131 West 33rd St. About $325,000. Work will be done by day labor.

N. Y., New York—The Wendell Estate, c/o B. H. & C. N. Winston, Archts., 2 Columbus Circle, will build a 4 story, 51 x 116 ft. office building including a steam heating system at 1900-8 B'way. Work will be done by day labor under supervision of architect.

N. Y., Sherman Island (Glens Falls P. O.)—The International Paper Co., 30 Broad St., New York City, has awarded the contract for a hydro-electric plant here, to the Barclap Constr. Co., 84 Pine St., New York City, at $5,000,000.

N. J., New Brunswick—The Artic Ice Co., 56 French St., has awarded the contract for a 3 story, 50 x 100 ft. storage plant to N. A. Bugbee Co., 206 East Hanover St., Trenton, at $75,000. Ice machinery will be installed.

O., Cleveland—The Cleveland Land & Security Co., Union Bldg., will build an office building including a steam heating system. About $300,000. Work will be done by day labor.

Ind., Indianapolis—The National City Bank, 14-16 East Washington St., has awarded the contract for a 14 story bank and office building including a steam heating system to the Hoggson Bros., 485 5th Ave., New York City, at $1,000,000.

Wis., Jefferson—The Jefferson Rubber Co., c/o C. Girton, will build a 1 story, 80 x 320 ft. tire factory including a steam heating system and is in the market for one 150-hp. high pressure boiler. About $100,000. Work will be done by day labor.

Minn., Lester Prairie—The City has awarded the contract for a feed water heater and stack, one 300 g.p.m. electric motor-driven pump and connections, and pipings to J. G. Robertson, 2542 University Ave., St. Paul, at $1,692.

Kan., Baxter Springs—The General American Oil Co., 604 New 1st Nat'l Bank Bldg., Tulsa, Okla., will build by day labor, an oil refinery here, and will require boilers. Contract for steam pipes awarded to the General Iron Wks., 604 New 1st Nat'l Bank Bldg., Tulsa, Okla.

Col., Lafayette—The Great Valleys Sugar Co., 800 Central Savings Bank Bldg., has awarded the contract for a sugar factory to Schwartz Eng. Co., Mack Bldg., at $1,000,000.

N. B., St. John—The Dept. Pub. Wks., Ottawa, Ont., has awarded the contract for the installation of a heating system in the Immigration Building to R. E. Fitzgerald, St. John, at $18,500. Noted Sept. 7.